ANNALS

OF

The Entomological Society of America

— — — —

VOLUME XXIII, 1930

PUBLISHED QUARTERLY BY THE SOCIETY
COLUMBUS. OHIO

CONTENTS OF VOLUME XXIII.

CONTENTS OF No. 1.

CONTENTS OF No. 2.

CONTENTS OF No. 3.

CONTENTS OF No. 4.

ANNALS

OF

The Entomological Society of America

Volume XXIII MARCH, 1930 Number 1

THE ANT PRENOLEPIS IMPARIS SAY.*

WILLIAM MORTON WHEELER,
Harvard University.

To the myrmecologist the ants that belong to the ancient preglacial circumpolar fauna are of unusual interest, and among these none is more deserving of study than the small, shining, brown or yellowish *Prenolepis imparis*, because it is almost indistinguishable from *P. henschei* Mayr, a species that flourished in the amber forests of the Lower Oligocene Tertiary of northern Europe. In addition to its great antiquity and its extraordinary morphological stability throughout postoligocene time, *P. imparis* also exhibits certain behavioristic peculiarities which have not been sufficiently emphazied in the literature.

A. Distribution and Ethology of P. imparis.

As redefined by Emery in 1906, the genus Prenolepis contains only eight described species, namely *acuminata* Forel of Mexico, *gibberosa* Roger of Cuba, *imparis* Say of North America, *jerdoni* Emery of Indomalaya, *melanogaster* Emery of Upper Burma and Indochina, *nitens* Mayr of Europe, *naoroji* Forel of Hindoustan and the above-mentioned fossil species *henschei* of the Baltic amber. This list, however, will have to be reduced because *acuminata* is very probably a Paratrechina and not a Prenolepis, and *nitens*, as I shall show, is a mere variety of *imparis*. Furthermore, *imparis* itself is scarcely more than a variety of the extinct *henschei*. At any rate, the neotropical and paleotropical species *gibberosa*, *jerdoni*, *melanogaster* and *naoroji* are quite different from the group com-

*Contributions from the Entomological Laboratory of the Bussey Institution, Harvard University, No. 319.

prising the very closely interrelated *imparis*, *nitens* and *henschei*. Of course, the wide and discontinuous distribution of its various species is an argument in favor of the great age of the genus Prenolepis, which may actually have had its origin during the Eocene or Cretaceous.

Say described *P. imparis* ("*Formica imparis*") as long ago as 1835 from male and female specimens taken *in copula* in Indiana. The specific name obviously refers to "the great disparity in color and magnitude between the male and female." Mayr described *nitens* in 1852 as a Tapinoma, but in 1861 made it the type of his genus Prenolepis. Opinions on the status of this form have varied. Dalla Torre (1893) and Ruzsky (1905) regarded it as a variety, and Emery (1910) as a subspecies of *imparis*, but in 1916 he raised it to specific rank, citing as his reasons the circumscribed geographical range of *nitens*, the stouter body and shorter appendages of its worker and the more heavily infuscated wings of its sexual forms, as compared with *imparis*. He was unable to detect any noticeable differences in the male genitalia.

P. nitens is confined to a limited area (shown in the map Fig. 1 B), as will be seen from the following data: Mayr records it from Tyrol, Carinthia, Transylvania and Dalmatia; Roger from Croatia, northern Turkey and Constantinople; Forel from Herzegovina, Albania, Cattaro, Corfu, Attica in Greece, Lesbos and Bulgar Dagh, in Asia Minor; Santschi from Roumania and Ruzsky from the western Caucasus and the Black Sea district. It just enters Italy at the head of the Adriatic, occurring, according to Emery at Palmanova. More recently Finzi has found it near Trieste in Venezia Julia and on the island of Cherso, off the Dalmatian Coast. It would seem, however, that *P. nitens* must be a rather rare or sporadic ant, because its citation in recent lists of Formicidæ from the Caucasus, Balkan Peninsula and Asia Minor is very infrequent. In some of the older literature it is recorded as occurring in a few localities in western Europe. In 1855 F. Smith described an ant as *Tapinoma polita*, later regarded as a synonym of *P. nitens*, from a single worker specimen captured at Bournemouth, England, and Bingham (1906) recorded *nitens* as living in the tropical fern house of the Kew Botanic Gardens. According to Bos (1887) both von Vollenhoven and Ritsema recorded this ant from the Leyden Botanical Garden. Donisthorpe (1908)

could no longer find it at Kew and Blote (1924) failed to find it in Leyden. It was obviously introduced into both botanical gardens with plants or soil, and it is now impossible to state whether the form was really *nitens* from Eastern Europe or the typical *imparis* from North America. The workers of the two forms are so similar that even an expert myrmecologist might fail to distinguish them. I possess three workers and three

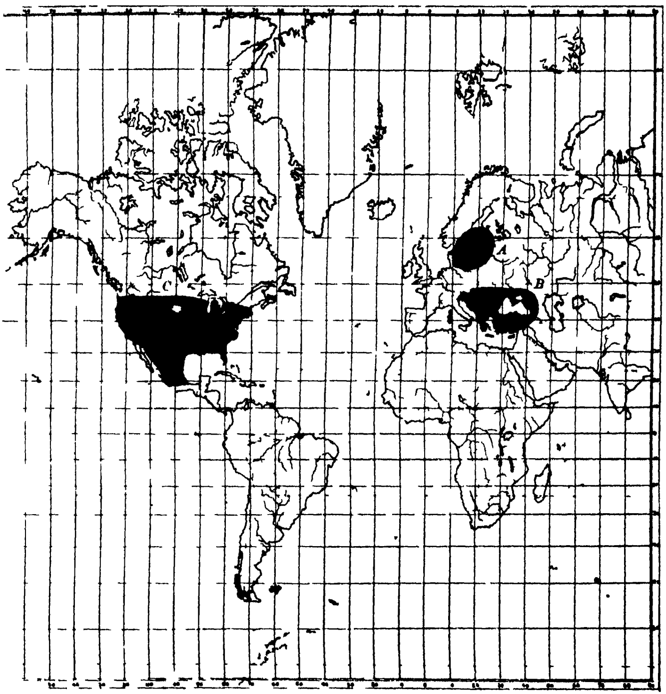


Fig 1 Distribution of Prenolepis. A, *P. henschei* Mayr of the Baltic amber; B, *P. imparis* var. *nitens* Mayr; C, *P. imparis* sens. str and its North American varieties

males of the typical *nitens* from Lesina, Dalmatia, received many years ago from G. Mayr. The workers are indistinguish able from dark forms of *imparis* from the Atlantic states and though the wings of the males are somewhat darker than in most forms of *imparis*, there are western varieties with wings of the same color as *nitens*. The present circumscribed or discontinuous distribution of the latter is no reason for regarding it as a distinct species, since the same argument would require

us to regard the North American and Eurasian forms of *Camponotus herculeanus*, *C. caryæ*, *Formica sanguinea*, *F. fusca*, *Leptothorax acervorum* etc. as distinct species. In the case of *P. imparis* and *nitens* the discontinuity of distribution is merely greater.

A study of the American specimens of *P. imparis* that have been accumulating for many years in my collection, shows a remarkably wide distribution, covering nearly the whole of the United States, at least a portion of Ontario and the highlands of Mexico as far south as the states of Vera Cruz and Colima. In general, therefore, the range of the species in North America extends from lat. 19° to about 46°. Emery (1893) distinguished three forms of *imparis:* the type, a var. *testacea* and a var. *minuta*, and I have described in the sequel six additional varieties- *pumila*, *californica*, *arizonica*, *coloradensis*, *veracruzensis* and *colimana*. All of these and Emery's varieties are based on rather feeble and elusive characters and are in part connected by intermediate forms, so that the species as a whole may be said to exhibit little morphological variation though it is sufficiently unstable in such characters as stature, pilosity, and color to permit recognition of certain feebly differentiated geographical forms (subraces).

Very little is known concerning the habits of the var. *nitens*. Finzi (1921) found it to be rather common in certain localities under stones in very moist places. The American forms, according to my observations, very rarely nest under stones, but make obscure crater nests, usually with a single small orifice, in shady places.* The typical *imparis* prefers moist, clayey soil, the var. *testacea* sandy soil or pure sand. The nests occur so frequently near oaks, even if they belong to our dwarf "scrub" species, that one suspects some definite association between the ants and these plants. Moreover, the general range of *imparis* and the oaks in North America is nearly conterminous, though the latter extend somewhat farther south (to Gautemala) and somewhat farther north (to Nova Scotia). Yet even within its general range *imparis* seems to be lacking over considerable areas, especially in the Rocky Mountain region. Much more intensive observation in the field will be required before its precise ecological distribution

---

*Dr. A. H. Sturtevant has recently informed me that the variety described below as *californica* regularly nests under stones.

can be determined. This is difficult, because the ant is very timid and retiring and perhaps to some extent crepuscular or even nocturnal. At least it seems to avoid the open sunlight and to be most active in the shade and on cool or cloudy days. I have found the young dealated queens, which closely resemble those of *Lasius niger*, founding independent incipient colonies in small chambers in the soil.

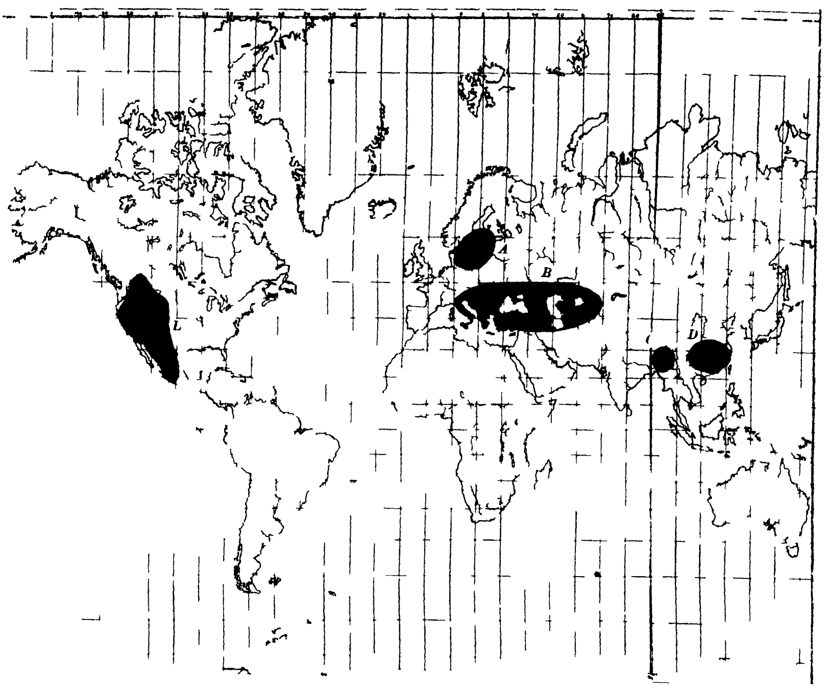


Fig. 2. Distribution of the species of Liometopum. A, *L. oligocenicum* Wheeler of the Baltic amber; B, *L. microcephalum* Panzer; C, *L. lindgreeni* Forel; D, *L. sinense* Wheeler; E, Distribution of *L. apiculatum* Mayr and *occidentale* Emery, covering the area of the fossil species *L. miocenicum* Carpenter and *scudderi* Carpenter in the Miocene of Colorado.

The food of *P. imparis* consists of liquid, especially the "honey-dew" of aphids and coccids, the nectar of flowers and extrafloral nectaries, the exudates of living oak-galls, the juices of dead earthworms and those derived from the young tissues of plants. These various liquids are imbibed in such quantities by the foraging workers that their gaster become

greatly distended (Fig. 3) and make their gait very unsteady. In this condition they are really "repletes" like those of the true honey-ants of the Southwestern States and Mexico (*Myrmecocystus melliger* and *mexicanus*). The feeding of *imparis* (var. *californica*) on young plant-tissues has been recently called to my attention by Mr. H. M. Armitage and indicates that these small timid ants may become of some economic importance. He writes me that in Los Angeles County, Cal., they "were observed feeding extensively not only on the calyx and unopened petals of fruit buds of oranges, but also on the tender new growth. This condition was credited to the fact that the ants become active before the normal citrus bloom and at a time when little natural feeding was available." Mr. A. C. Burrill has recently made very interesting observations on the feeding habits of *imparis* and its singular resistance to cold in the Arnold Arboretum at Forest Hills, Mass., and in Missouri, and permits me to quote some of his unpublished notes:

"I was led to make continuous observations on *P. imparis* after casually noticing that it appeared at the surface of the soil later in the fall and earlier in the spring than any of our other ants. During the rather warm winter of 1927-28 I selected for daily observation a nest with two entrances in the Arnold Arboretum. The workers were observed to come out onto the surface of the soil nearly every week throughout the winter. The lowest temperatures recorded when the ant came out were on February 6, 1928, when the temperature in the early morning was 6° F. (26° below freezing). At noon, less than eight hours later, a worker appeared at the surface though the soil was still frozen. On February 25 a worker passed from one entrance to the other with a sharp wind blowing at 27° F., as recorded by a tested thermometer at one inch above the ground. The sun, however, induced a thaw, so that the temperature of the ground was really 33.5° F. Tests with honey enticed more of the workers out of doors till the surface cold had fallen to 30° F, when the surface of the soil was frozen and the ants brushed against hoarfrost around their entryway. Honey does not freeze at such a temperature and ants can still lap it up slowly.

"On cool, humid middays below 60° F. workers may remain active above ground all day, but seldom stay in the bright

sun or on dry soil. They are at their best during or after cold rains, or a cold, humid period with overcast skies They were most active outdoors between 35° and 55° F. all winter, but they occasionally crawled over the soil below 30° F. or above 60° F. One case of great activity occurred when a colony moved to a new site during a drizzle and kept excavating the new nest down into the subsoil with air-temperature about 60° F.

"For about five months these ants lived on dead or dying earthworms driven above ground by rains. If other food was

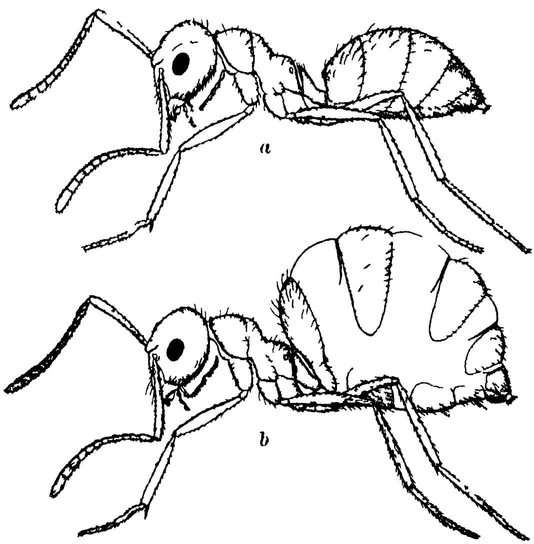


Fig. 3 *Prenolepis imparis* Say *a*, worker in ordinary condition, *b*, same in the "replete" condition.

available besides honey-dew or honey that had been stored in the crops of the repletes during the fall, I failed to discover it. I often saw *imparis* leave an earthworm that had been dried up by the sun and return to it as soon as another rain had soaked it up again.

"Similar observations were made in regard to the winter activities of *imparis* at Jefferson City, Mo., during the winter of 1928-29. The ants were nesting in trodden, clayey, poorly drained loess soil. The workers were excavating December 14, 15 and 16, which were followed by a heavy freeze-up.'

Mr. Burrill's observations show that the ants do very little excavating during the winter but that this sets in suddenly a few days before the nuptial flight. This, as I have frequently noticed, takes place as early as the latter fortnight of March or the first fortnight of April. That the period must be much the same for the different varieties and over a considerable portion of the United States is indicated by the following dates of nuptial flights recorded in my notebooks, on the labels of mounted males and winged females or in the literature:

P. imparis (typical). Forest Hills, Mass., March 15 and 25; April 4, 5 and 6; Bridgetown, N. J., March 28; Albany, N. Y., March; Wauwatosa, Wis., April 20; Jefferson City, Mo., March 19, 20 and 21; Lawrence and Riley Co., Kansas, March, April 2.

var *testacea*. Bronxville, N. Y., April 10; Plummer's Island, Maryland, April 12.

var. *minuta*. District of Columbia, April; Cape May, N. Y., March 24.

var. *californica*. Stanford University, Cal , Jan. 30, Feb. 23, and March 19.

The winged sexes that participate in the nuptial flights mature during the late summer of the previous year and are retained in the nests over winter. I have found males and winged females of the var. *testacea* at Lakehurst, N. J. in the nests on September 24. This retention of the sexual phases over winter occurs in a few of our other northern ants, e. g. in the various varieties of *Camponotus herculeanus* and of *C. caryæ*, but in these cases the flight is later, usually in May or June, or even in July. The very early flight of *imparis* was first observed in Indiana by Say., who says: "They appeared in great numbers on the 2nd of April; the males swarmed around small bushes, alighting on the branches and leaves. The females were few." I have seen such flights of the males about the Japanese barberry bushes in the Arnold Arboretum on fine days in late March and early April. The males dance up and down in rather compact swarms like the late summer swarms of male bees of the genus Chloralictus.*

*The date and form of the marriage flight in ants are really specific characters and are clearly adaptations to the ecological conditions. Kusnezov-Ugamsky (1927, 1929) has called attention to certain peculiarities in the flights of ants in the deserts of Turkestan. He finds that they are very unfavorable to the flights at certain seasons, especially during the summer, probably, I surmise (I cannot read the Russian text), because the soil is then too dry and hot and the young recently fecundated queens are unable to dig deeply into it, or because the winds are too severe and make mating difficult. The species of Messor (*rufus* and *barbatus*), which are completely adapted to a desert life, therefore have their flights in the early spring (March and beginning of April), after overwintering the males and females in the nest. In the exquisitely deserticolous species of Cataglyphis the marriage flight has been suppressed. The females leave the nests singly and run

Both Burrill's observations on its activity during the winter months and those on its very early nuptial flight indicate that *P. imparis* may be regarded as negatively thermotropic, or adapted to cold, unlike our other ants which are distinctly thermophilous, or thermotropic.† This is also indicated by the nesting habits of *imparis*. There are numerous observations on the hibernation of some of the more common ants of the north temperate zone. The behavior of most of them during the cold months is like that recently described by Holmquist (1928) in his study of *Formica ulkei* in northern Illinois. He found in this species that the activity of the workers at the surface of the nest declined gradually from September 10 to November 1, after which date they remained dormant in clusters in their galleries below the frost line. On April 2, as soon as the frost had disappeared from the ground they gradually revived and returned to the surface but it was not till May 14 that the hibernation aggregations had completely broken up. "The hibernation period of this species was a prolonged one (5 to 8 months). The winter of 1924-25 was not unusually long for the Chicago region, and it is assumed that

---

about or skip nimbly over the surface of the soil with the aid of their wings like Pompilid wasps. I have also observed this peculiar behavior of Cataglyphis species in June and July in the desert regions of Morocco and Southern Spain. Kusnezov-Ugamsky believes that the absence from the deserts of Turkestan of whole genera, such as Formica, Lasius and Myrmica, is due to the fact that their species have stabilized their flight for midsummer and it is precisely at this season that the desert offers the most unfavorable conditions. My observations on the ants of our Southwestern deserts do not agree with Kusnezov-Ugamsky's interpretation, except in the case of Veromessor, which is very closely related to the Old World Messor. I have found many males and winged females in the nests of V. *pergandei* as early as March 9 and April 20, so that they must winter over and fly in the spring, but the sexual forms of *Novomessor cockerelli* and *albosetosus* do not develop until early June. Various species of Pogonomyrmex have their marriage flights from June to August in the deserts of Texas, Arizona and California, and I have described (1917) those of *Moellerius versicolor* and the nestfounding of recently fecundated queens of *Myrmecocystus melliger mimicus* in the Arizona desert on July 30. This was just after a cloudburst, however, when the soil was very damp and the air was clear and still. I believe that the conditions for summer marriage flights of ants, owing to occasional rains at that season, must be much more favorable in our American deserts than in those of Turkestan.

†The number of insects that remain active out of doors at low temperatures during the late fall, winter and early spring has been underestimated. Frison (1927) has called attention to this in his valuable paper on the fall and winter stoneflies (Plecoptera). It is significant that these as well as the more famous species of Boreus and Chionea and *Desoria glacialis*, the "glacier flea," all belong to very primitive groups. Miss N. Ford (1926) has called attention to the resistance to cold of *Grylloblatta campodeiformis*, another ancient form: "If placed in a large vessel containing pieces of ice the insects keep close to the ice, on it or under it, and as the ice melts, forming miniature streams, the Grylloblattæ readily wade them."

this period is normal for this species. As compared with the hibernation period of most insects it is a long one." Steiner (1925) has shown that the temperature of dormant, hibernating aggregations of *Formica rufa* and *Lasius niger* in Switzerland is essentially that of the surrounding soil. In a later paper (1929) he demonstrates that while in bees and to a less extent in social wasps the nest-temperature is determined by the physiological, or body heat produced by the insects themselves, this is not the case in *F. rufa* and *exsecta*, but depends on the structure of the nest as an arrangement for securing and conserving the physical heat, or that due to diurnal insolation. The latter even in mound nests, like those of *rufa*, is retained only during a portion of the night, whereas in nests that are merely mined in the soil (crater nests), the heat of insolation is lost at nightfall.

These facts lead to a consideration of the differences between mined, or crater nests and those excavated in the soil under stones, and suggest that the exclusive occupation of crater nests in moist, poorly drained soil in the shade may be regarded as a further indication of the negative thermotropism of *P. imparis*. I have already mentioned the fact that this ant, in Eastern North America, almost never lives in nests under stones. Now the great majority of temperate region ants live either in crater nests or in the soil under stones and the prevalence of one or the other according to temperature and humidity presents an interesting and complicated ecological problem. In the desert regions of Africa, Asia, North America and Australia the crater nest is the common and often the only type of nest observed (see also Kusnezov-Ugamsky 1925). In such regions there is no need to conserve the heat of insolation in the nests. The soil temperature, in fact, is often too high for the comfort of the ants, so that they suspend all activities at the surface, remain in the depths of their galleries during the hottest hours of the day and forage only in the cool of the morning or evening or at night.

Forel (1874) was, I believe, the first to call attention to the great prevalence of nests under stones at high elevations in the mountains and his observations have been confirmed by Steiner (1929), who has given a careful analysis of this type of nidification. Stones that are not too small are very advantageous at high altitudes because they protect the nest from wind and other inclemencies of the weather, the too rapid evaporation

of moisture from the soil beneath them and above all, because they are rapidly heated by the sun and transmit their heat to the surface galleries. They have the disadvantage, however, compared with the mounds of vegetable débris accumulated by such ants as *Formica rufa*, *exsecta*, etc. in losing their heat rapidly by radiation after nightfall. Nevertheless, nests under stones are very common also in rather dry climates even at low altitudes, as in many parts of the United States Indeed, many of the common circumpolar species nest in this country under stones, though the same or closely allied forms in Central Europe, where the soil and atmospheric humidity is greater, prefer to construct small mound nests or those with at least some accumulation of earth or débris over the excavated galleries to act as capturers and storers of the feebler heat of insolation and thus serve as incubators for the brood during the early summer months. Quite a number of ants, however, nest under stones in the shade of woods, thickets, etc. Some of our species, like those of the genera Ponera, Stigmatomma, Myrmecina, Stenamma, Aphaenogaster, Brachymyrmex, all Acanthomyops and some Lasius, require only moderate warmth and the shaded stones probably take up from the air and transmit to the soil sufficient heat during the breeding season. These ants, however, seem to demand a greater or more equable soil moisture than those which nest under stones exposed to the sun. I have introduced this digression as tending to throw the singularity of *P. imparis* into stronger relief, since this ant, as a rule, merely mines its nests rather deeply into damp, shaded soil and fails to take advantage even of the slight heat-storage of the stones that are often found in its immediate environment.

Besides its cryophily, or negative thermotropism there are two other negative peculiarities of *P. imparis* worth mentioning. One is its failure to keep root aphids or coccids in its nests, like the species of Lasius, Acanthomyops and Brachymyrmex so common in the same situations. This may seem surprising, because *imparis* is so fond of honey-dew, till we consider that the habit of keeping root Homoptera is probably amply compensated by its ability to develop repletes capable of storing large quantities of liquid food. It is not so easy to account for the fact that the nests of an ant so defenceless and so addicted to feeding by regurgitation, contain no guests or

myrmecophiles. At least there is no record of such an occurrence, though *imparis* is very common in the Atlantic States where coleopterists and other entomologists have long been searching the nests of our various Formicidæ for myrmecophiles. In this connection the occurrence of pseudogynes in Prenolepis is interesting. In 1914 I described two pseudogynes of *P. henschei* from the Baltic Amber and more recently have found one of *P. imparis* var. *testacea* among some workers from Georgia. Though apparently very rare, the occurrence of such pathological stages between female and worker are worthy of note, because their presence can hardly be attributed to the infestation of the colony with larva-devouring symphiles, as in the case of the famous pseudogynes of *Formica sanguinea*.

If it be true, as I believe, that the American and Eurasian forms of *P. imparis* are scarcely more than varieties of the Upper Oligocene *henschei*, we may suppose that the latter had a wide circumpolar distribution during the Early and Middle Tertiary and that the living forms represent the remnants of that fauna after its southward displacement by the Pliocene glaciation. This is also Emery's opinion (1920). He accounts for the present distribution of the var. *nitens* on the supposition that it was exterminated north of the Alps, which formed a barrier to its southward migration in western Europe, but managed to survive in the southeast by escaping through the gap between the Balkan Alps and the Caucasus. *P. nitens* is therefore a glacial relict which, after the return of a milder climate, has spread over the limited area it now occupies. In North America, on the other hand, the north-south trend of the mountain ranges permitted a more extensive southward migration, survival and subsequent partial northward reoccupation of the original territory of the species. Not improbably, however, *imparis* in North America may have actually suffered very little displacement beyond the southern border of the ice-sheet. In this connection the ant's negative thermotropism might be supposed to have been acquired during the Glacial Epoch, but there seems to be another way of accounting for this resistance to cold, as I shall suggest in the sequel.

Emery has called attention to the resemblance of the present distribution of *P. imparis* to that of the ants of the Dolichoderine genus Liometopum. This is shown in the accompanying maps (Fig. 1 and 2). In the Old World the

genus comprises two fossil and three extant species. In 1914 I described one of the former, *L. oligocenicum*, from the Baltic amber, and Mayr (1867) had previously described the other, *L. antiquum*, from the Radoboj-shales of Lower Miocene age.* The three living Old World species comprise, first, the well-known *L. microcephalum* Panzer, which covers the range of *P. imparis* var. *nitens* but has a wider distribution, extending to Italy and Sicily, Southern Russia, the Eastern Caucasus and Turkestan and therefore occupying a territory enclosing the Adriatic, Black, Caspian and Aral Seas; second, *L. lindgreeni* Forel, inhabiting Assam and, according to Bingham, also Upper Burma; and third, *L. sinense* Wheeler, which seems to be widely distributed in Southern China. In North America there are three species, two fossil, namely *miocenicum* and *scudderi*, both recently described by Carpenter (1930) from the Miocene shales of Florissant, Colorado, and two living species, *L. occidentale* Emery of California and Oregon and *L. apiculatum* Mayr, with several subspecies, in part still undescribed, and ranging over the warmer lower slopes of the mountains from Southern Alberta to the State of Colima in Mexico, but not east of the hundredth meridian in the United States. The species of Liometopum are so closely interrelated that a conservative "lumper" might regard them all as varieties of a single species. Comparison of the two maps (Figs. 1 and 2) shows that the species of Liometopum, though discontinuous in their individual ranges, together occupy a much more extensive territory than the varieties of *imparis*. It will be seen also that the Liometopums are confined to xerothermal mountain areas. They are even more conspicuously associated with oaks than *imparis*, and build large, finely trabecular, carton nests in the cavities of their trunks. The colonies are very populous and aggressive, though frequently, at least in North America, harboring numerous Staphylinid myrmecophiles (*Apteronina schmitti* Wasm. and *Dinardilla liometopi* Wasm.). The velvety, strong-smelling workers forage in dense files on the vegetation where they secure honey-dew and miscellaneous insect food. For a more detailed account of the habits of

*I doubt the generic identification of this ant. The type is a female, described as only 5 mm. long, whereas this sex in all the other species is much larger. Moreover, the workers of the still older *oligocenicum* are as large as those of the living species. I regard two other described fossil species from Radoboj, *imhoffi* Heer and *schmidti* Heer, as even less probably referable to the genus Liometopum.

L. microcephalum the reader may be referred to the papers of Emery (1891) and Forel (1892) and for observations on *L. apiculatum* and *occidentale* to one of my early papers (1905).

While we may assume that the earliest known ancestors of both *P. imparis* and *Liometopum* are represented by *P. henschei* and *L. oligocenicum* respectively of the Baltic amber, it does not necessarily follow that the latter belonged to the same geological age. We have long known that among the amber insects there are two distinct faunal components, one closely related to our present circumpolar, north temperate species, the other more closely related to the tropical or subtropical species of the Indomalayan and Australian Regions. It has been assumed, therefore, either that the formation of the amber must have covered a long period with two different, successive climates, or that the specimens represent a mixture of contemporary forms which, however, actually lived at very different altitudes. That the ancient Samland was mountainous is indicated by Ulmer's study of the amber caddice-flies, which belong partly to modern genera whose larvæ live in torrential waters and partly to those whose larvæ inhabit sluggish streams or pools. A palaeobotanist, Professor E. W. Berry (1927), has recently expressed himself as follows on the climatic conditions in which the amber forests flourished: "As I picture the amber forests from the evidence of the plants my picture agrees fairly well with that which modern authorities derive from a study of the insects, namely that we have a mixture of forms whose existing relatives still live at the same latitude with others whose relatives now live in warmer climes. Certainly, the climate was temperate and not in any sense tropical. This is clearly indicated by the abundance and variety of coniferous trees, as well as by the northern element in the insect faunas; but among them we find representatives of a number of warm temperate types, and I think we are justified in concluding that the climate was much more genial, and the floras and faunas much more extensive and varied than in the Samland of the present time."

The more southern distribution of both *P. imparis* and Liometopum at the present time as compared with their distribution during the Lower Oligocene not only confirms Berry's description of the Samland climate but also suggests that their range during the earlier Tertiary (Eocene and Paleocene)

may have extended to an even higher latitude, where the climate was like that of Western Greenland as indicated by the studies of Seward (1927), who describes from that region Cretaceous remains of coniferous and quercine trees, if not of actual oaks. If Prenolepis and Liometopum were components of such a polar ant-fauna we can easily account for the present distribution of the two genera in both hemispheres. The resistance to cold on the part of *P. imparis*, therefore, may have been acquired during its long and very gradual southward displacement before the glacial period. The more xerothermal Liometopum is not improbably an older, Cretaceous genus which had reached its present habitat in Early Miocene times. The northern portion of the range of the New World species, *apiculatum*, was probably annexed after the recession of the glaciers.

B. Taxonomy of P. imparis.

As previously stated, this ant is so constant morphologically that it seems inadvisable to assign more than varietal, or subracial status to any of the forms that can be recognized among the materials in my collection. I therefore redescribe all three phases of the typical *imparis* and subjoin brief descriptions of the nine varieties, which in part at least, represent incipient geographical races. More material, especially from the Rocky Mountain states and northern Mexico, will probably reveal the existence of several additional varieties.

Prenolepis imparis (Say) Mayr.

(Fig. 3, Fig. 4a).

Formica imparis Say, Boston Journ. Nat. Hist. 1. 1836, p. 287, ♀ ♂.
(?) *Tapinoma polita* F. Smith, Trans. Ent. Soc. London (2) 3, 1855, p. 112, ☿, Dale, Ent. Month. Mag. 17, 1881, p. 236, ☿; White, Ants and Their Ways, 1883, p. 257.
Formica (Tapinoma) Wichita Buckley, Proc. Ent. Soc. Phila 6, 1866, p. 169, ☿.
(?) *Tapinoma nitens* E. Saunders, Trans. Ent. Soc. London, 1880, p. 211, ☿; Ent. Month. Mag. 20, 1881 p. 270, ☿.
Prenolepis nitens Mayr., Verh. Zool. Bot. Ges. Wien. 36, 1886, p. 431, ☿.
Prenolepis imparis Mayr. *Ibid.* 36, 1886, p. 431, ♀; Dalla Torre, Cat. Hymen. 7, 1893, p. 178, ☿ ♀ ♂; Emery, Zool. Jahrb. Abt. Syst. 7, 1893, p. 635, ☿ ♀ ♂; Wheeler, Bull. Amer. Mus. Nat. Hist. 21, 1905, p. 390, fig. 1, ☿ ♂; Occas. Pap. Boston Soc. Nat. Hist. 7, 1906, p. 11; Psyche 20, 1913, p. 116; Proc. Amer. Acad. Arts Sc. 52, 1917, p. 523; Emery, Gen. Insect. Formicinæ, 1925, p. 225, ☿ ♀ ♂.
Prenolepis nitens var. *americana* Forel, in Grandidier, Hist. Madagascar 20, 1891, p. 94, Pl. 3, fig. 4, ♂.
Prenolepis (Nylanderia) imparis Emery, Ann. Soc. Ent. Belg. 50, 1906, p. 133, 134; Wheeler, Bull. Amer. Mus. Nat. Hist. 24, 1908, p. 385, fig. 26, ☿.

Worker. Length 3-4 mm.

Head as broad as long, slightly narrower in front than behind, with straight posterior border and feebly rounded sides and posterior corners. Eyes moderately convex, nearly one-fourth as long as the sides of the head, and situated a little behind its middle. Mandibles rather flat, with convex external borders, their apical borders feebly oblique, 6-toothed, the apical and basal tooth largest, the former strongly curved, the third tooth from the tip minute. Maxillary palpi very long, reaching to the occipital foramen. Clypeus convex in the middle, subcarinate behind, depressed on the sides, its anterior border broadly rounded and entire. Frontal area large but indistinctly defined; frontal groove absent; frontal carinæ feeble, short and subparallel. Antennæ slender; scapes extending about two-fifths their length beyond the posterior corners of the head; first funicular joint as long as the subequal second and third together; joints 2-8 nearly twice as long as broad, remaining joints somewhat shorter, except the last, which is as long as the two penultimate joints. Thorax small and slender, divided into two portions by a deep constriction of the posterior part of the mesonotum; the promesonotum somewhat longer than broad, evenly convex and subhemispherical above, the dorsal outline not interrupted at the promesonotal suture, the mesonotum anteriorly as long as broad, subtrapezoidal a little broader in front than behind, sloping downward and passing posteriorly into the constricted portion which bears on its dorsal surface the pair of somewhat projecting metathoracic spiracles close to the base of the epinotum. The latter is subrectangular from above and nearly as broad as long, in profile with subequal base and declivity, the former slightly convex and rising posteriorly where it has a faint longitudinal impression and forms a distinct but rounded angle with the declivity. This is broad and flat, with its projecting spiracles near the middle of its sides. Petiole as long as high, its node strongly inclined forward, in profile compressed and cuneate, with feebly convex anterior and posterior surfaces and rather acute border; seen from behind it is trapezoidal, broader above than below, with straight sides and a transverse superior border, which is straight or very slightly concave in the middle. Gaster proportionally large, broad anteriorly, tapering behind to a point, convex above, the basal segment concave anteriorly where it overlies the petiole, its anterior border above straight and transverse in the middle and forming a distinct angle on each side. Legs rather slender.

Very smooth and shining; mandibles glossy, very finely longitudinally striate; head and thorax with small, sparse, piligerous punctures; gaster very finely, superficially and tranversely shagreened, with coarser piligerous punctures, and along the posterior borders of the segments with minute, hair-bearing tubercles.

Hairs and pubescence whitish or pale yellowish, the former rather coarse, erect or suberect, pointed, of unequal length, more abundant on the head and gaster than on the thorax, longest on the gaster. Cheeks, gula and front also with conspicuous short, sparse, appressed hairs, or very coarse pubescence. Antennæ with abundant fine, oblique

hairs or pubescence, longest and most conspicuous towards the tips of the scapes. Legs with very short, sparse, inconspicuous, appressed or subappressed pubescence.

Varying from pale castaneous to dark piceous brown, the thorax and anterior portion of the head usually paler, the gaster darker and more blackish; mandibles, antennæ, legs, including coxæ and posterior edges of gastric segments, brownish yellow or yellowish brown. Palpi pale yellow, mandibular teeth black.

Female. Length 7.5–8.5 mm.; wings 7–7.5 mm.

Head broader than long and more narrowed anteriorly than in the worker. Eyes rather large; ocelli small and close together. Thorax massive, broader than the head, from above broadly elliptical, dorsally somewhat flattened in profile; mesonotum as long as broad; scutellum large; epinotum small, subperpendicular, rounded, without base or declivity. Petiolar node broad, thick below, strongly anteroposteriorly compressed above, its superior border deeply excised in the middle. Gaster large, oblong-elliptical, its basal segment angulate on each side anteriorly as in the worker.

Less shining than the worker, with the mandibles more coarsely striate and the head, thorax and gaster much more densely punctate.

Erect hairs shorter and more numerous than in the worker. Head, thorax and gaster covered with yellowish appressed pubescence which, however, is not sufficiently dense to conceal the shining and punctate integument. A similar but somewhat shorter pubescence covers the antennæ and legs.

Reddish brown; mandibles, antennæ and legs slightly paler and more reddish. Wing membranes uniformly yellowish brown; veins and pterostigma resin-colored.

Male. Length 3.5–4 mm.

Head, including the eyes, broader than long, broadly rounded behind, without posterior corners, narrowed anteriorly, with short, straight cheeks. Mandibles rather large and overlapping, but with only the apical tooth developed Clypeus large, less convex than in the worker. Antennal scapes slender, about one-third as long as the long funiculus; first joint of the latter small, of the usual shape, about one and one-half times as long as broad; remaining joints broader, of uniform width, twice as long as broad, the penultimate joints somewhat shorter, the last as long as the two preceding joints together. Thorax not broader than the head; mesonotum convex anteriorly, distinctly broader than long; epinotum evenly rounded and sloping in profile, without distinct base and declivity. Petiolar node shaped somewhat as in the worker, but much thicker, inclined forward, with blunt apical border, straight and transverse but not impressed in the middle. Gaster elongate-elliptical; external genital appendages long, somewhat curved, uniformly tapering and blunt at the tip. Legs slender; hind tibiæ feebly bent near the middle.

Shining and finely punctate; antennæ and legs more finely and densely than the remainder of the body; mandibles very finely striate as in the worker.

Hairs grayish, rather soft and flexuous, long and abundant on the head and thorax and very conspicuous on the tip and venter of the gaster. Pubescence long, sparse and appressed, most distinct on the gaster, very fine and short on the legs, slightly longer and more oblique on the scapes.

Piceous black; antennæ and mandibles dark brown; femora black, the trochanters, tips of femora, the tibiæ and tarsi brownish yellow. Wings varying in color from whitish to grayish hyaline, with colorless or pale yellowish veins and pterostigma.

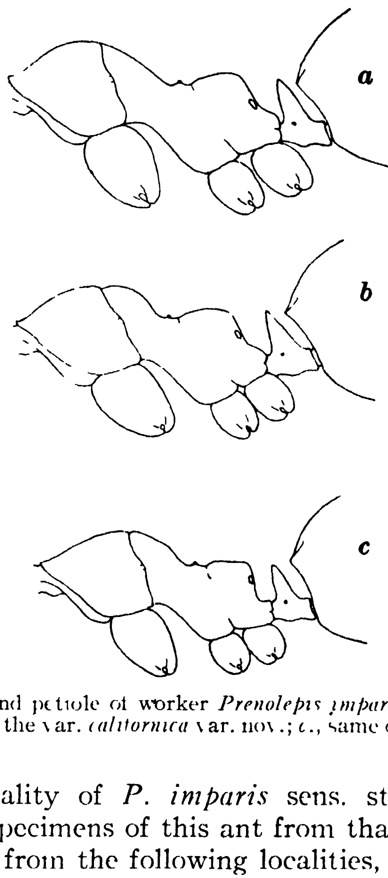


Fig 4. *a.*, Thorax and petiole of worker *Prenolepis imparis* sens. str. in profile; *b.*, same of the var. *californica* var. nov.; *c.*, same of the var *coloradensis* var. nov.

The type-locality of *P. imparis* sens. str. is "Indiana." I have seen no specimens of this ant from that state, but have series or records from the following localities, which show that it is widely distributed over the eastern half of the United States and Southern Ontario, from Massachusetts to Missouri and south to Georgia, Mississippi and Texas:

Ontario: Grimsby.
Ohio: Hocking County (M. R. Smith).
Pennsylvania: Beatty (J. Schmitt); Harrisburg.
New Jersey: Fort Lee and Halifax (W. M. Wheeler); Clementon; Ramsey; Burlington (T. J. Headlee); Caldwell (Cresson); Camden County (Fox).

New York: Central Park, New York City and Brooklyn (H. von Krockow), Bronxville and Cold Spring Harbor, L. I. (W. M. Wheeler); Wyandach, L. I. (F. M. Schott); Conesus, Clinton Heights, Callicoon, White Plains and Van Cortland Park (J. Bequaert); Tottenville, New Brighton, Watchogue, Long Neck and Annandale, S. I. (W. T. Davis and J. Bequaert); Amagansett, Yaphank, Calverton, Montank, Pinelawn, Wading R., Gardner's I. and Cold Spring Harbor, L. I. (W. T. Davis and J. Bequaert).
Maryland: District of Columbia (T. Pergande); Plummer's I. (W. L. McAtee).
North Carolina: Tryon (W. M. Wheeler); Black Mt. (B. Muller); Lake Toxoway (Mrs. A. T. Slosson).
Georgia: Thomasville; Clayton, 2,000-3,700 ft. (W. T. Davis).
Mississippi: Holly Springs (T. F. McGehee).
Connecticut: New Haven and Yalesville (H. Viereck); Branford (Winckley); New Haven (Britton).
Massachusetts: Forest Hills and Blue Hills (W. M. and G. C. Wheeler); Danvers (H. W. Winckley); Wareham (C. A. Frost); Milton (A. P. Morse); Essex County and Springfield (G. B. King); Warwick (Miss Edmonds); Woods Hole and Falmouth (A. H. Sturtevant).
Illinois: Rockford (W. M. Wheeler).
Wisconsin: Wauwatosa (G. Graenicher).
Missouri: Jefferson City (A. C. Burrill).
Kansas: Douglas County (C. Klaumann); Lawrence (Tucker); Riley County (J. B. Norton).
Texas: Denton (W. H. Long).

P. imparis var. nitens (Mayr.)

Tapinoma nitens Mayr, Verh. Zool. Bot. Ges. Wien. 2, 1852, p. 144, ☿; *Ibid.* 5, 1855, p. 377, ☿; Progr. Realsch. Pest. 1856, p. 15, ☿.
(?) *Tapinoma polita* F. Smith, Trans. Ent. Soc. London (2) 3, 1855, p. 112, ☿.
Prenolepis nitens Mayr, Europ. Formicid. 1861, p. 52, ☿; Ern. André, Spec. Hymen. Europ. 2, 1882, p. 204-206, ☿ ♀ ♂; Emery, Bull. Soc. Ent. Ital. 47, 1918, p. 238, Fig. 78, ☿ ♀ ♂; Genera Insect. Formicinæ, 1925, p. 225, ☿ ♀ ♂.
(?) *Tapinoma nitens* E. Saunders, Trans. Ent. Soc. London, 1880, p. 211, ☿; Ent. Month. Mag. 20, 1881, p. 270, ☿.
Prenolepis imparis var. *nitens*, Dalla Torre, Cat. Hymen. 7, 1893, p. 178, ☿ ♀ ♂; Ruzsky, Formicar. Imper. Ross. 1905, p. 262, fig. 50, 51, ☿ ♀ ♂.
Prenolepis imparis subsp. *nitens* Emery, Deutsch. Ent. Zeitschr. 1910, p. 128, fig. 1, ☿ ♀ ♂.
Formica crepusculascens Roger, Berlin. Ent. Zeitschr. 3, 1859, p. 238, ♀; *Ibid.* 6, 1862, p. 256, ♂.
Lasius (?) *crepusculascens* Mayr, Europ. Formicid. 1861, p. 51, ♀

Worker. Length 3-3.5 mm.

Very similar to the common dark form of the typical *imparis*. Brown, with piceous black gaster; antennæ somewhat paler and more yellowish brown than the head and thorax. Superior border of petiolar node somewhat more impressed in the middle. Pilosity and pubescence very similar but the legs have somewhat longer and more oblique, i.e. less appressed, hairs and the pubescence on the antennæ is perhaps slightly longer and denser.

Female. Length 9 mm.; wings 8.5 mm.

Very similar to the female of the typical *imparis* but apparently darker, being piceous instead of reddish brown; the wings also darker brown, with dark brown viens and pterostigma. Pubescence on the antennæ and legs somewhat shorter and more appressed than in the worker.

Male. Length 3-3.5 mm.

Also very similar to the male of *imparis* sens. str. and also black or dark piceous brown, but the wings are darker, being tinged with brown and having pale brown veins and pterostigma. The tibiæ, too, are darker and more brownish. Pilosity and pubescence very similar.

Northeastern corner of Italy, Tyrol, Austria, Balkan Penninsula, Asia Minor and Caucasus.

The description of the female, which I have not seen, is adapted from Emery.

P. imparis var. testacea Emery.

Prenolepis imparis var. *testacea* Emery, Zool. Jahrb. Abt. Syst. 7, 1893, p. 636, ☿ ♂; Wheeler, Bull. Amer. Mus. Nat. Hist. 21, 1905, p. 390, ☿; Psyche 30. 1913, p. 116, ☿; Emery, Genera Insect. Formicinæ, 1925, p. 225, ☿; M. R, Smith, Ent. News, 39, 1928, p. 278, ☿.

Worker. Differing from the typical *imparis* in color, being yellow, or brownish or reddish yellow, with the gaster and posterior portion of the head often darker and varying from pale to dark brown. Legs yellow. Quite as smooth and shining as the type, with the same pubescence and pilosity.

Female. Distinctly paler and more yellowish red than the typical *imparis;* mesonotum with a broad brown parapsidal streak on each side and often with a narrower antero-median streak of the same color. Wings of the same yellowish brown tinge as in *imparis,* with resin-colored veins and pterostigma.

Male. Brown or yellowish brown, with darker head; legs yellow, with the femora brownish except at their tips; antennæ of the same color as the body. Wings slightly tinged with yellowish; veins and pterostigma brownish.

District of Columbia: Washington (T. Pergande), type-locality.
Virginia: (T. Pergande).
North Carolina: Tryon (W. M. Wheeler); Black Mt. and Swannanoa (W. Beutenmueller).
Georgia: Clayton, 2,000-3,700 ft. (W. T. Davis); Gainesville, Tybee Isl., Marietta and Atlanta (J. C. Bradley).
Florida: St. Augustine (C. T. Brues), Tallahassee.
Mississippi: Agricultural and Mechanical College (M. R. Smith).
New Jersey: Lakehurst (W. T. Davis and W. M. Wheeler); Clementon and Medford (H. Viereck).
New York: Mosholu, Bronxville, Van Cortland Park, Central Park, New York City and Arlington, S. I. (W. M. Wheeler); Tottenville, S. I., Wading R. and Amagansett, L. I. (W. T. Davis and J. Bequaert); Ithaca (Funkhauser); Taughannoc Falls, Ithaca (C. P. Haskins).
Pennsylvania: Beatty (J. Schmitt).
Missouri: Columbia (A. M. Ferguson).
Arizona: Indian Garden, Grand Canyon (W. M. Wheeler).

Unlike the typical *imparis, testacea* prefers to nest in pure sand or sandy soil at low altitudes. Its distribution shows

that it is a southern form, most abundant in the Carolinian area of Southern New Jersey and southward to Florida.

P. imparis var. minuta Emery.

Prenolepis imparis var. *minuta* Emery, Zool. Jahrb. Abt. Syst. 7, 1893, p. 636, ☿ ♂; Wheeler, Occas. Papers Boston Soc. Nat. Hist. 7, 1906, p. 11, ☿; Emery, Genera Insect. Formicinæ, 1925, p. 225, ☿ ♂.

Worker. Length 2–2.5 mm.

Closely resembling the typical *imparis* in sculpture, pilosity and color but decidedly smaller.

Female. (undescribed). Length 6.5 mm.; wings 6.5 mm.

Also smaller than the females of any of the preceding forms, somewhat paler than *imparis* and darker than *testacea*, with the mesonotal markings of the latter and the wing-membranes somewhat paler than in either of these forms.

Male. Length 2.5 mm.

Indistinguishable from the male of *imparis*, except in its smaller size and in having slightly darker wings. Veins and pterostigma pale yellowish.

District of Columbia: (T. Pergande), type-locality.
North Carolina: Clemson Agricultural College, (M. R. Smith and W. A. Morrison).
New Jersey: Cape May and Bridgetown (F. M. Schott).
Connecticut: New Haven and Yalesville (H. Viereck).
Indiana: Hammond and Wyandotte (W. Blatchley).
Wisconsin: Alma Center (A. C. Burrill).
Missouri: Barton County (J. W. Chapman)
Washington and Oregon: Columbia River Gorge (A. C. Burrill).

I possess two worker cotypes from the District of Columbia, two males from Cape May and Bridgetown, N. J., and a single female from the latter locality. In stature this variety, which has a wide distribution though it seems to be rather rare, closely resembles *P. henschei* of the Baltic Amber. The same is true of the following small variety.

P. imparis var pumila var nov.

Worker. Length 2.2–2.5 mm.

Of the same pale color as the var. *testacea* and bearing to it the same relationship in stature that the var. *minuta* bears to the typical *imparis*. The gaster, however, is paler and only slightly infuscated across the middle of each segment. Legs and antennæ pale yellow.

Male. Length 2.3–2.5 mm.

Colored like the male *testacea* but smaller; reddish brown; head darker brown posteriorly; femora, except their tips, brown like the thorax. Wings grayish hyaline, with pale brownish veins.

North Carolina: Raleigh (F. Sherman), type-locality.
Alabama: Fort Payne (W. S. Creighton).
District of Columbia: Washington (T. Pergande).
New York: New York City (C. T. Brues).

P. imparis var. **coloradensis** var. nov.

(Fig. 4, c).

Worker Length 2.5–3 mm.

Resembling the var. *pumila* but averaging somewhat larger and darker in color, being brown, with the gaster and posterior portion of the head scarcely darker than the thorax; posterior borders of gastric segments, antennæ and legs yellow. Distinguished from all the preceding forms by the shape of the epinotum, which has the base decidedly shorter than the declivity and forming with it a much more pronounced angle, almost a right angle, in fact, because the declivity is much more nearly perpendicular. Upper border of petiolar node seen from behind straight and transverse, with less rounded corners.

Numerous specimens from Cheyenne Mt., 8000 ft., near Colorado Springs, Colorado (W. M. Wheeler).

P. imparis var. **arizonica** var. nov.

Worker. Length 3–3.5 mm.

Of the same color as darker specimens of the var. *testacea;* thoracic sutures, mandibles, coxæ, legs and antennæ brownish yellow. Pilosity distinctly longer and on the gaster conspicuously more abundant; pubescence on antennal scapes somewhat longer. Upper border of petiolar scale distinctly concave in the middle. Base of epinotum rather short but in other respects the thorax is shaped as in the typical *imparis* and the var. *testacea*.

Female. Length 6.5 mm.; wings 7.5 mm.

Smaller than the female of *imparis*, its vars. *nitens* and *testacea* and colored like the last, but without mesonotal markings. Wings quite as dark but less yellowish and with brownish yellow veins and brown pterostigma. Pubescence on head, thorax and gaster much longer. Petiolar node broader, with more rounded sides above and distinctly narrower and shallower emargination in its superior border.

Male. Length 3–3.2 mm.

Dark piceous brown, with black head; antennæ and legs throughout as dark as the thorax and gaster. Wings decidedly darker than those of any of the preceding forms, including the var. *nitens*, uniformly dark grayish, with dark brown veins and pterostigma.

Described from four workers, three males and a single female taken by Dr. W. M. Mann in Ramsay Canyon, Huachuca Mts. 5800 ft. Arizona. In all probability, this form occurs also in the mountains of northern Mexico.

P. imparis var. **californica** var. nov.

(Fig. 4, b).

Worker. Length 2.3–2.5 mm.

Averaging smaller than the typical *imparis* and usually of the same color, but often darker and almost black, more rarely paler and approaching the var. *testacea*. Antennæ and legs brown, tarsi paler and more yellowish. Eyes distinctly smaller, mesonotum more convex, so that the curved dorsal outline is more interrupted at the promesonotal suture than in *imparis;* the constricted posterior portion of the mesonotum very short and the metathoracic spiracles therefore closer to the posterior end of the mesonotal declivity. Petiolar node narrower, more compressed anteroposteriorly, with more flattened anterior and posterior surfaces and sharper superior border. The latter less transverse, not concave. Long pilosity on the body much as in *imparis*, the pubescence on the scapes and legs longer and less appressed.

Female. Length 6–6.5 mm.; wings 7.3 mm.

Smaller than the female of the typical *imparis;* either dark brown and therefore of the same color or paler and more reddish. Wings darker and more brownish, with brown veins and pterostigma. Thorax somewhat broader and higher; petiolar node thinner, with less deeply excised superior border.

Male. Length 2.8–3.2 mm.

Also smaller than the male of the typical *imparis;* black or piceous black, with brown antennæ and legs, tarsi and knees somewhat paler. Wings gray, darker than in the typical *imparis*, with more distinct brown veins and pterostigma, as in the var. *nitens*. Erect pilosity abundant on the head, thoracic dorsum and gaster, very conspicuous on the venter. Eyes somewhat smaller and less convex than in imparis; petiolar node not so thick above.

California: Stanford University (H. Heath, W. M. Mann, C. F. Baker), type-locality; San Jose (H. Heath); Marin County; Eldridge, Sonoma County (J. A. Kusche); Piedmont and Berkeley (J. C. Bradley); mountains near Claremont (C. F. Ba' er); Santa Cruz Island (R. V. Chamberlin); Point Loma, San Diego (P. Leonard); Santa Inez Mts. and San Ysidro, near Santa Barbara, Pasadena, Mt. Lowe and Yosemite Village (W. M. Wheeler); Santa Paula (H. F. Quayle); Portola; La Verne (E. Becker).
Nevada: Ormsby County (C F. Baker).
Oregon: Ashland (W. Taverner); Forest Grove (A C. Burrill).

This form, which seems to be confined to the Pacific coast region, is rather unstable and may have to be resolved into several distinct varieties when more material, especially of the females and males, is available for study. The workers from La Verne, Calif. are very dark, those from Santa Cruz Island and Point Loma approach the var. *testacea* in color, but those from the vicinity of San Francisco are colored like the typical *imparis*. The specimens which I collected on Mt. Lowe are

reddish brown and vary greatly in size (from 2-3.5 mm.). They have unusually long and suberect pubescence on the scapes and legs and seem, therefore, to be transitional to the following two varieties from Mexico.

P. imparis var. **veracruzensis** var. nov.

Worker. Length 3 mm.

Resembling the typical *imparis* but uniformly brownish red, except the tarsi and knees, which are yellow. Head subrectangular, as broad in front as behind. Promesonotum and petiole shaped as in *imparis;* base of epinotum more convex, rising posteriorly and rounding into the longer declivity without any indication of an angle. Pubescence on scapes and legs long, conspicuous and less appressed, even longer than in the above-mentioned form of *californica* from Mt. Lowe.

Described from a single specimen taken in sweepings by Dr. A. Dampf at Maltrata, Altaluz, in the State of Vera Cruz, Mexico. Till more material is available the status of this variety is problematic. It is obviously closely related to the following:

P. imparis var. **colimana** var. nov.

Worker. Length 3-3.5 mm.

At first sight resembling dark forms of the typical *imparis.* Rich castaneous brown, the posterior portion of the head and the gaster darker and more blackish; antennæ, trochanters, tarsi and bases and tips of femora paler, more yellowish brown. Head, thorax and petiole shaped as in *imparis*, but stouter. Erect hairs on the body longer and more abundant and the pubescence on the scapes and legs much longer, more abundant and more nearly erect than in any of the other varieties. The scapes appear plumose, owing to their pubescence being longer than their greatest diameter and even the funiculi have unusually long and conspicuous pubescence.

Described from numerous specimens taken by Mr. C. H. T. Townsend on the Volcan de Colima at an altitude of 7500 ft., in the state of Colima, Mexico.

LITERATURE.

1927. **Berry, E. W.** The Baltic Amber Deposits. Scient. Monthl. 24, 1927, pp. 268-278, 3 figs.
1906. **Bingham, C. T.** Formicidae in "The Wild Fauna and Flora of the Kew Botanic Gardens." Bull. Misc. Inform. Roy. Bot. Gard. Kew Addit. Ser. 5, 1906, pp. 27-29.
1887. **Bos, H.** Iets over de Nederlandsche Mierenfauna. Tijdschr. v. Ent. 30, 1887, pp. 181-198.
1930. **Carpenter, F. M.** Fossil Ants of North America. Bull. Mus. Comp. Zool. 70, 1930 pp. 3-66, 11 pls.
1908. **Donisthorpe, H. S. J. K.** Ants found in Great Britain. Trans. Leicester Lit. Phil. Soc. 12, 1908, pp. 221-233.
1927. **Donisthorpe, H. S. J. K.** British Ants, their Life-history and Classification, 2nd edit. London, 1927.
1891. **Emery, C.** Zur Biologie der Ameisen. Biol. Centralbl. 11, 1891, pp. 168-173.
1893. **Emery, C.** Beitrage zur Kenntnis der nordamerikanischen Ameisen. Zool. Jahrb. Abth. Syst. 7, 1893, pp. 633-682, 1 pl.
1906. **Emery, C.** Note sur Prenolepis vividula Nyl. et sur la classification des espèces du genre Prenolepis. Ann. Soc. Ent. Belg. 50, 1906, pp. 13-134, 5 figs.
1910. **Emery, C.** Beitrage zur Monographie der Formiciden des palaarktischen Faunengebietes. Teil X. Deutsch. Ent. Zeitschr. 1910, pp. 127-132, 9 figs.
1916. **Emery, C.** Fauna Entomologica Italiana. Formicidae. Bull Soc. Ent. Ital. 47, 1916. 201 pp., 92 figs.
1920. **Emery, C.** La distribuzione geographica attuale delle Formiche. Real. Accad. der Lincei 317, 1920, pp. 357 450.
1925. **Emery, C.** Genera Insect rum. Subfamily Formicinae. 1925.
1921. **Finzi, B.** Primo contributo allo conoscenza della fauna mirmecologica della Venezia Julia. Boll. Soc. Ent. Ital. 53, 1921, pp. 1-3.
1921. **Finzi, B.** Terzo contributo alla conoscenza della fauna mirmecologica della Venezia Julia. Boll. Soc. Ent. Ital. 59, 1927, pp. 7-10.
1926. **Ford, N.** On the Behavior of Grylloblatta. Canad. Ent. 58, 1926, pp. 66-70, 1 fig.
1886. **Forel, A.** Nouvelles fourmis de Grèce récoltées par M. E. von Oertzen. C. R. Soc. Ent. Belg., 1886, 10 pp.
1888. **Forel, A.** Ameisen aus den Sporaden; den Cycladen und Greichenland gesammelt von Herrn von Oertzen. Berlin. Ent. Zeitschr. 32, 1886, pp. 255 265.
1892. **Forel, A.** Die Ameisenfauna Bulgariens. Verh. zool. bot. Ges. Wien. 42, 1892, pp. 308 309.
1913. **Forel, A.** Fourmis de la fauna méditerranéenne récoltées par MM. U. et J. Sahlberg. Rev. Suisse Zool. 21, 1913, pp. 427-438.
1929. **Frison, T. H.** Fall and Winter Stoneflies, or Plecoptera, of Illinois. State Illinois Dept. Registr. Educ. Nat. Hist. Survey 18, 1929, pp. 345-409, 77 figs.
1928. **Holmquist, A. M.** Studies in Arthropod Hibernation. II. The Hibernation of the Ant, Formica ulkei Emery. Physiol. Zool. 1, 1928, pp. 325-357, 5 figs.
1925. **Kusnezov-Ugamsky, N.** Der Nestbau turkestanischer Ameisen als ökologischer Verbreitungsfaktor. Zool. Anzeig. 64, 1925, pp. 253 260.
1926. **Kusnezov-Ugamsky, N.** The Geographical Relations of the myrmecological Fauna of the Caucasus (in Russian) (period ?), 1926, pp. 63-74.
1927. **Kusnezov-Ugamsky, N.** On the Marriage Flight of Ants. (In Russian). Rev. Zool. Russe 7, 1927, pp. 77-104.
1929. **Kusnezov-Ugamsky, N.** The Ants of the Genus Messor in the Fauna of Middle Asia. Act. Univ. Asiae Mediae, ser. 8a, 1929, 25 pp., 3 pls.
1852. **Mayr, G.** Beschreibung einiger neuen Ameisen. Verh. zool. bot. Ges. Wien. 2, 1852, p. 143-150.

1855. **Mayr, G.** Formicina austriaca. Verh. zool. bot. Ges. Wien. 5, 1855, pp. 273–478, 1 pl.
1861. **Mayr, G.** Die Europäischen Formiciden. Wien 1861, VIII + 80 pp., 1 pl.
1867. **Mayr, G.** Verläufige Studien über die Radoboj-Formiciden. Jahrb. K. K. geol. Reichsan. Wien 17, 1867, pp. 47062, 1 pl.
1886. **Mayr, G.** Die Formiciden der Vereinigten Staaten von Nordamerika. Verh. zool. bot. Ges. Wien 36, 1886, pp. 419-464.
1905. **Ruzsky, N.** Formicariae Imperii Rossici. (In Russian). Kasan, 1905.
1910. **Santschi, F.** Contributions à la faune Entomologique de la Roumanie. Bul. Soc. Stiinte, 1910, pp. 648–651.
1835. **Say, T.** Descriptions of New North American Hymenoptera and Observations on Some Already Described. Boston Journ. Nat. Soc. 1, 1835, pp. 210-305.
1927. **Seward, A. C.** Plant-bearing Rocks of Western Greenland. Phil. Trans. Roy. Soc. London B, 215, 1927, pp. 57–175, 9 pls.
1925. **Steiner, A.** Temperaturmessungen in den Nestern der Waldameise (Formica rufa var. rufo-pratensus For.) und der Wegameise (Lasius niger L.) Wahrend des Winters. Mitteil. Naturf. Gesell. Bern., 1925, pp. 1-12.
1929. **Steiner, A.** Temperaturmessungen in Ameisennestern mit Erdkuppeln, im Nest von Formica exsecta Nyl. und in Nestern unter Steinen. Zeitschr. vergleich Physiol. 9, 1929, pp. 1–66, 25 figs.
1905. **Wheeler, W. M.** The North American Ants of the Genus Liometopum. Bull. Amer. Mus. Nat. Hist. 21, 1905, pp. 321–333, 3 figs.
1908. **Wheeler, W. M.** Honey Ants, with a Revision of the American Myrmecocysti. Bull. Mus. Nat. Hist. 24, 1908, pp. 345-397, 28 figs.
1910. **Wheeler, W. M.** Ants, their Structure, Development and Behavior. New York, 1910.
1914. **Wheeler, W. M.** The Ants of the Baltic Amber. Schrift physikal. okonom. Gesell. Konigsberg 55, 1914, pp. 1–142, 66 figs.
1917. **Wheeler, W. M.** Notes on the Marriage Flights of Some Sonoran Ants. Psyche 24, 1917, pp. 177–180.

ON THE NOMENCLATURE FOR THE BROODS OF PERIODICAL INSECTS.

H. PREILL,*
Forstliche Hochschule, Tharandt, Germany.

While the majority of insects have at most an annual cycle of generation, thus in the course of a single year passing through one or several complete series of developmental stages, there are, on the other hand, many species that need several years for their development. It is characteristic of insects of the second group that the imagines appearing in one year are not the offspring of imagines from the year immediately preceding, but are the progeny of parents that appeared as imagines in a more distant year. Since the duration of development for each species is fairly constant locally, it is then possible to distinguish as many broods for each particular species as there are years in its developmental cycle.

It frequently happens, however, that of the theoretically possible number of broods of a species, one brood appears in a particular locality with an abundance of individuals (main brood), while the other broods (secondary broods) may have a much smaller number of individuals, or may not be known to be represented at all. From a practical standpoint, the main brood can play a conspicuous role, because, if the insect is one of economic importance, the years of its appearance may be years of great destruction. Consequently there is in literature an abundance of comment on the periodical recurrence of injurious insects.

If we wish to make a comprehensive synopsis from such information, it is necessary to have a brief designation for the broods, or for the brood years. There is, however, so great a lack of uniformity in the terms by which the broods of periodical insects have been distinguished, that it is often difficult to make a comprehensive summary; and because of these different systems of nomenclature that have been used for different

*The writer is deeply indebted to Mr. R. E. Snodgrass for having supervised the translation of this paper.

insects there is an urgent need for a truly clear and precise method for naming the broods applicable to all periodic species. A brief review will show how broods of periodical insects have thus far been designated.

The simplest method for naming a brood consists of identifying it with a year in which it appeared, or perhaps one in which it was particularly destructive. This method of naming the brood years, as employed by J. B. Smith with reference to the periodical cicada, is not satisfactory because there may mature in the same year several broods of the same species, but of different length of development. Moreover, the selection of different brood-years of the same brood for the designation of this brood may easily result in confusion.

As a rule, therefore, by the use of a year as a brood name, there is selected for the designation not only one flight-year but several years which have been recorded of the repeated occurrence of the same brood in the same locality, and which naturally are characteristic of the brood in question. The method of naming broods according to the year sequence, as 1901-04-07, has been employed by many writers, and is still commonly used for the European May-beetle. This method can be applied successfully only in individual cases, because in comparative investigations of the brood years in various localities, the series of years exactly ascertained in one place may come out quite different in another, and consequently may be very confusing.

By many writers, again, the broods of periodical insects are designated by proper names taken from localities in which the appearance of the insect is characteristic. The oldest instance of this kind is that of the naming of the broods of the May-beetle in Switzerland as the Bern brood-year (1834), the Uri brood-year (1835), and the Basel brood-year (1836), a system invented by O. Heer. This method of designating the broods is unquestionably convenient for local faunistic studies; it cannot be applied, however, in comprehensive investigations, because it is impossible for one who does not know the flight-year of the broods in the locality taken as characteristic, either from his own experience or from the published records, to find the connection between the name of the brood and the series of brood years or vice versa.

Still other writers have designated the broods by means of figures, a custom generally adopted in works on the periodical cicada. In such cases numbers are given to broods determined by exact records of the years of flight, regardless of the character of the brood series. If this enumeration is made without a special plan (Fitch), the number of each brood might remain unchanged, since a new number may be given to any newly discovered brood. This system, however, must result eventually in a loss of all relation between the series of brood years and the series of identification numbers. If, on the other hand, the enumeration of the broods is made to correspond with the time of the serial recurrence of the brood-years after an arbitrarily fixed date (Riley selected the year 1868, which was a particularly important brood year with both races of the periodical cicada), the discovery of a definite new brood might upset the numbering completely and cause utmost confusion. This is proved only too well by a comparison of the brood nomenclature used by Walsh and Riley (1868), and by Riley (1869). Moreover, the number system was made still more unwieldly by the fact that no consideration was given to the difference in duration of development, and that any broods, regardless of their developmental periods, appearing in the same year were simply given a number in the series. Consequently, this method neither led to any definite results, nor was it of practical use without a key.

Later the numbering system was improved by taking into account all the theoretically possible broods of the species (Marlatt). Thus by continuing the sequence of numbers after a date selected as a starting point, subsequent changes in the numbers were finally avoided. (Marlatt took the year 1893 for the beginning in his series of numbering, this year being the first of a long series of actually observed brood-years of the periodical cicada.) Notwithstanding this improvement, however, and recognizing the fact that both races of the periodical cicada were now distinguished in the numbering, the method is useful only within certain limits, because it does not show clearly the relation between the name of a brood and its place in the series of brood years. (Marlatt enumerated the broods of the 17-year race of the periodical cicada from I to XVII, and those of the 13-year race from XVIII to XXX.)

NOMENCLATURE OF THE BROODS OF THE PERIODICAL CICADA.

Year	Proposed General Method of Designation	Enumeration of Broods				Record of Appearance: Typical Years
		Complete	Incomplete			
			Based on Sequence of Broods		Absolute	
		Marlatt 1898	Riley 1869	Walsh & Riley 1868	Fitch 1854	Smith 1857
XIII	**Cicada (Magicicada) v. tredecim** Walsh and Riley.					
1901	*XIII/1	XXVI	X	....	....	1849
1902	XIII/2	XXVII	....	....	....	....
1903	XIII/3	XXVIII	....	....	....	....
1904	XIII/4	XXIX	....	....	....	....
1905	XIII/5	XXX	...	....	....	....
1906	XIII/6	*XVIII	XVI	....	....	1854
1907	XIII/7	XIX	XVIII	XIII	3 p. p.	*1812
1908	XIII/8	XX	*II	....	....	1843
1909	XIII/9	XXI	IV	....	....	1844
1910	XIII/10	XXII	VI	IV	....	1845
1911	XIII/11	XXIII	VII	V	5 p. p.	1846
1912	XIII/12	XXIV	....	....	....	....
1913	XIII/13	XXV	....	....	....	....
1914	*XIII/1	XXVI	X	....	....	1849
1915	XIII/2	XXVII	....	....	....	....
1916	XIII/3	XXVIII	....	....	....	....
1917	XIII/4	XXIX	....	....	....	....
1918	XIII/5	XXX	....	....	....	....
1919	XIII/6	*XVIII	XVI	....	....	1854
1920	XIII/7	XIX	XVIII	XIII	3 p. p.	*1812
....	....	....	....	....	....	....
XVII	**Cicada (Magicicada) septendecim** Linne					
1901	*XVII/1	IX	XXI	XV	....	1850
1902	XVII/2	X	XXII	XVI	4	1851
1903	XVII/3	XI	*I	*I	9	1852
1904	XVII/4	XII	(III)	II	....	1853
1905	XVII/5	XIII	V	III	6	1854
1906	XVII/6	XIV	VIII	VI	3 p. p.	1855
1907	XVII/7	XV	....	....	....	....
1908	XVII/8	XVI	IX	VII	....	....
1909	XVII/9	XVII	....	....	....	....
1910	XVII/10	*I	XI	....	....	*1842
1911	XVII/11	II	XII	VIII	1	1843
1912	XVII/12	III	XIII	IX	....	1844
1913	XVII/13	IV	XIV	X	....	1845
1914	XVII/14	V	XV	XI	5 p. p.	1846
1915	XVII/15	VI	XVII	XII	7	1847
1916	XVII/16	VII	XIX	....	....	1848
1917	XVII/17	VIII	XX	XIV	2, 8	1849
1918	*XVII/1	IX	XXI	XV	....	1850
1919	XVII/2	X	XXII	XVI	4	1851
1920	XVII/3	XI	*I	*I	9	1852

*=First brood of the enumeration.

It is thus evident that none of the methods so far used for designating the broods of periodical insects is entirely satisfactory. It is, therefore, necessary to devise a new and better system of nomenclature.

Considering the objections which have been urged against former and current methods of naming the broods of periodical insects, we should consider some of the requirements necessary for a satisfactory brood nomenclature. The following three points are essential:

1. Clear and concise designations for the broods.
2. A ready deduction of a flight-year sequence from the name given to a brood, and the reverse.
3. A uniform and simple application of the system to all periodical insects.

These requirements are fulfilled if the name of the brood shows the duration of the generation, indicating thus the number of potential broods, if it gives the position of a particular brood of a series, and if it designates a characteristic brood year. These essentials may be combined in one symbol by naming the broods of a periodical insect with a suitable double number.

The first of the two figures to be used is given by the number of years in the generation period of the insect, or the number of possible broods of the species or race in the same time, the two figures being identical. The second figure is furnished by the numerical order of the particular brood in the series after the time at which the numbering is begun, which should be the first year after the beginning of the century. Thus the sequence number of the brood will be also the number of the year in which the brood theoretically first appeared after the beginning of the present century.

It is more convenient for several reasons to express the first number with a Roman numeral and the second with an Arabic figure, and to separate the two with an oblique line.

The use of this new method of nomenclature will exclude all misunderstanding, and should, therefore, facilitate the study of periodical insects. Naming the broods as above proposed will show all that is characteristic of each particular brood. For example, II/1 shows that the brood of an insect so designated belongs to a species having a two-year life cycle and that it flies in the

years of odd numbers; the designation IV/3 means that the brood is of an insect having a four-year developmental period, and that it flies in a year before a leap-year. Further examples are given in another place (*Zoologischer Anzeiger*, Vol. 81. Leipzig 1929, pp. 203–219).

This same method of brood naming might be applied also to insects having several generations in one year, the broods in this case being indicated by letters. Thus I/3/b would designate the second of three possible broods of an insect having several generations each year.

Since this nomenclature is especially suitable for insects with long developmental periods, it seems appropriate to add, in conclusion, a comparative synopsis of the various designations used to distinguish the broods of the two races of the periodical cicada, including the nomenclature here proposed. The advantages of the last thus become selfevident.

BOOK NOTICE.

INSECT PESTS AND THEIR CONTROL IN SOUTH AFRICA, by Charles K. Brain, M. A , D. Sc. Die Nasionale Pers Beperk, Keerom Street, Cape Town.

Dr. Brain has presented in this book of nearly five hundred pages a most valuable survey of the insect pests of South Africa, one which must have a very useful place in the practical and the educational work of that rapidly developing commonwealth. There is a brief informative foreword by General J. Kemp, the Minister of Agriculture, and an introduction dealing with the general features of insect life followed by a series of chapters dealing with the different insect groups in a systematic order, a feature of special value to students, and these followed by a chapter on Beekeeping, one on Diseases transmitted by Insects and one on Control Measures. This latter sums up in a general way the different modes of control although control measures are presented in connection with the discussion of each important insect pest. Dr. Brain is to be congratulated on his success in compressing into convenient and workable form such a large amount of information concerning insects of so many groups and covering such an extended territory

HERBERT OSBORN.

A STUDY OF THE INSECT FAUNA OF BRAZOS COUNTY, TEXAS, WITH SPECIAL REFERENCE TO THE CICADELLIDÆ.

ROBERT K. FLETCHER,
Texas Agricultural Experiment Station.

Brazos County is situated in East Central Texas between the Brazos and Navasota Rivers, which form, respectively, its western and eastern boundaries. The two rivers meet at the southern extremity of the county. The old Nacogdoches-San Antonio Road is the northern boundary. The county is about 150 miles north of the Gulf of Mexico. The general elevation ranges from 200 to 400 feet above sea level. The topography as a whole is level to very gently rolling. The bottom land along the Brazos River varies in width from a few hundred feet to five miles. The Navasota River bottoms have an average width of nearly a mile. The greater part of the area has probably been a land surface since Oligocene time.

CLIMATE*.

A study of the climatological data of the county for the twelve years from 1916 to 1927, inclusive, gives the following results: Temperature, average mean, by months, January 50.25° F., February 55.37° F., March 60.02° F., April 67.46° F., May 74.17° F., June 80.05° F., July 83.71° F., August 83.99° F., September 78.85° F., October 69.49° F., November 59.62° F., December 52.41° F. Rainfall, average mean, 39.94 inches. The periods of highest average temperature and lowest average rainfall coincide, resulting in a well defined period of summer drought. During the twelve years included two periods of extended droughts have occurred. The first from August 1, 1916 to February 1, 1918, during which time of eighteen months but 20.38 inches of rain fell. The second from July 1, 1924 to

AUTHOR'S ACKNOWLEDGMENTS.—These studies were started and completed under the direction of Dr. Herbert Osborn, to whom the author is indebted for advice, encouragement, and the identification of Cicadellidæ. The late Mr. H. Ness, Botanist of the Texas Agricultural Experiment Station, identified many plants and gave much valuable information as to their ecology and distribution.

*These data are compiled from the records of the Texas Agricultural Experiment Station. They were made available through the courtesy of Mr. A. B. Conner, Director of the Station.

August 1, 1925, during which period of fifteen months but 15.75 inches of rain fell. An examination of the records shows also an uneven distribution of rainfall throughout the year.

VEGETATION.

Brazos County lies in the Post Oak Region of the East Texas timber belt. This plant association has been described by Bray (1) and its extent determined. It is a westward extension on the lignitic soils of the forest of East Texas minus the pine. Post Oak (*Quercus stellata*) is the dominant tree species closely followed by Black Jack Oak (*Q. marilandica*). Upon the top of the escarpment along the Brazos and Navasota Rivers and extending a short distance back there is considerable hickory (*Carya sp.*). In fact Shantz and Zon (7) refer this region to the Oak-Hickory forest.

Along the rivers and smaller water-courses wherever there is sufficient moisture the Bottom Land Forest occurs. This consists of several species of Hickory (*Carya sp.*), Black Willow (*Salix nigra*), Cottonwood (*Populus deltoides*) Hornbeam (*Ostrya Virginiana*), several species of oaks, notably Overcup Oak (*Quercus lyrata*) and Water Oak (*Q. nigra*), White Elm (*Ulmus Americana*), Winged Elm (*U. alata*), Hackberry (*Celtis occidentalis*), Sweet Gum (*Liquidamber styraciflua*), Sycamore (*Platinus occidentalis*), Red Bud (*Cercis canadensis*), Honey Locust (*Gleditsia triacanthos*), Prickly Ash (*Xanthoxylon clava-herculis*), American Holly (*Ilex opaca*), Youpon Holly (*I. vomitoria*), Deciduous Holly (*I. decidua*), Flowering Dogwood (*Cornus florida*), Black Gum (*Nyssa sylvatica*), and Persimmon (*Diospyros Virginiana*). Black Walnut (*Juglans nigra*) and River Birch (*Betula nigra*) also occur in one locality known to the writer.

The upland forest was originally much more open than at present. Formerly there were very few shrubs and the trees were far apart with nearly pure stands of grass growing between, (Plate I, Fig. 1). Because of overgrazing the grass disappeared, its place being taken by shrubs, principally the youpons, the haws, and Indian Current. The disappearance of the grass also permitted the growth of many young trees of the same species as the original forest, namely oaks and hickories. We find at present a forest of closely set trees with an undergrowth of shrubs, (Plate I, Fig. 2).

The present "grassland" consists mostly of abandoned fields. Scattered through these are the grasses herein named and annuals which have increased in number of individuals in proportion as the grasses have been exterminated. In the youngest abandoned fields are found the Crotons or Sageweed (*Croton capitatus* and *C. Engelmannii*), especially the first, which covers hundreds of acres. Then come Broomweed (*Amphiachyris dracunculoides*) and Bitterweed (*Helenium tenuifolium*). Ragweeds (*Ambrosia sp.*) seem to come in next. After July, the above named weeds form the most characteristic feature of the vegetation of the old fields. Burr Clover (*Medicago hispida*) is very abundant in the spring, and it is spreading. Burmuda Grass (*Capriola dactylon*) is becoming dominant in many fields. One of the most widely distributed grasses at the present time, especially on the harder packed soils, is *Aristida sp.* Many fields have "gone back" to this grass. (Plate II, Figs. 1, 2).

In the northern and northwestern parts of the county a few small fields of the original grassland of the "blacklands" have been found. These fields have a few flowering plants scattered through them, but the dominant vegetation is grass. *Andropogon furcatus* and *A. scoparius* are the dominant grasses in the order given. (Plate I, Fig. 3).

Along the railway right-of-ways are found stands of mixed *A scoparius* and *A. saccharoides* and also unmixed stands of each of these plants. These railway right-of-ways are burned off each fall. It may be that in a way this approximates what took place before settlement. (Plate II, Fig. 3) shows a stand of *A. scoparius* with a slight mixture of *A. saccharoides*.

In the eastern part of the county *A. saccharoides* is quite plentifully scattered through old fields and in fence corners.

If these are relics, they point to a condition very different from the present, a condition in which grass was much more prevalent than now.

To summarize briefly, the original type of vegetation has been greatly modified. In place of the more or less open woodlands we find a heavy growth of comparatively young trees and thickets of shrubs. In place of the original grassland we find thousands of acres dominated by annual flowering plants. The effect of this change upon the insect fauna must have been profound.

Insects of the County.

LOCATION WITH REFERENCE TO TRENDS OF DIFFUSION.

According to Webster (10) there are two trends of diffusion passing through Texas. One of these reaches the United States from South America by way of the Antilles and Florida. It passes westward through the Gulf States and on to the Pacific Coast. The second trend enters North America by way of the Isthmus of Panama, extending northward to Yucatan where it divides. The eastern branch crosses to Cuba and joins the first trend. The western branch continues northward along the Gulf Coast to Texas and thence to Canada.

In connection with the first trend it should be remembered that Brazos County is located in the western edge of the forest which extends unbroken from the Atlantic Coast. With reference to the second trend, the Gulf Costal Prairie lies a few miles to the south and was formerly connected with the county in all probability by almost continuous grassland.

EFFECT OF SETTLEMENT.

The remains of the original vegetation are so meager that it is impossible to draw direct conclusions as to the nature of the original insect fauna. Observations, however, have been made by the author in certain families of insects which seem to point to a condition considerably modified from the original. These observations are recorded below.

Orthoptera (*Locustidæ*).—The number of individuals of many species is very great. Frequently they are very destructive to cotton. Conditions for breeding are ideal because of the thousands of acres of weed-filled fields which furnish food and also earth of the right consistency for oviposition. Little (4) records forty-seven species from the county.

Isoptera.—In certain parts of the county, especially along the escarpments of the rivers, termites are to be found in nearly every fallen log. Certainly conditions are better for this group of insects because of the increased amount of forest. Termites are spreading to the towns also, causing constantly increased damage.

Neuroptera (*Chrysopidæ*).—These are very abundant in cotton fields. There seems to be no doubt that this family has

increased in number of individuals with the introduction of cotton and cotton lice. The eggs of the Aphid Lions may be found on turnips, mustard, cabbage, and many other vegetables, and flowers and shrubs. The introduction of various plants upon which aphids feed in great numbers has surely increased the number of individuals of all aphid feeding insects.

(*Myrmeleonidæ*).—Areas of bare ground have increased with grazing and agriculture. Wherever these occur in places sufficiently shaded and undisturbed, Ant-lions are found in great numbers.

Ephemerida.—Occasionally May-Flies have been observed drifting along with the wind. The writer has not been able to determine where they come from. Settlement has probably affected this family to some extent. Very few of the streams are constant. Most are dry water courses except during rainy weather when they may become torrents. The removal of water-holding vegetation from much of the county has certainly reduced the number of constantly flowing streams and so lessened the chance for propagation of all insects adapted to such habitats.

Odonata.—A few species of Dragon-Flies have been observed. They are most abundant as to species and individuals near the Little Brazos River. A small clear-running spring-fed "branch" in the southern end of the county is the home of a number of Damsel-Flies.

There is probably an increased water-area in the county owing to the maintenance of "tanks" for watering the stock. Some of these are of considerable size and do not dry up during even the long droughts. It must be remembered in connection with water-insects that the land is much more subject to erosion than formerly and that consequently the few perpetual streams are muddy for long periods of time. The only exception to this rule known to the writer is the above-mentioned spring-fed "branch."

Thysanoptera.—These are very abundant on cotton, roses, and many wild flowers, especially the Compositæ. They have increased in numbers because of settlement.

Hemiptera (*Miridæ*).—For evidence as to the effect of settlement upon the increase in numbers of individuals of insects, see Reinhard (6) on *Psallus seriatus* (Reut.). This

insect has thirty-eight food plants. At least thirty of these are weeds. The crotons, which cover hundreds of acres of abandoned land in the county, are the favorite food plants. Under certain conditions they leave these plants to attack cotton, sometimes ruining the crop. The cotton Leaf-bug (*Adelphocaris rapidus* Say) has been taken from weeds, and no doubt it leaves these to attack cotton. Various species of Lygus have also been taken from weeds.

(*Coreidæ*).—The two Leaf-Footed Plant Bugs (*Leptoglossus phyllopus* Linn.) and (*L. oppositus* Say) are also found first on weeds and then on cotton.

(*Pentatomidæ*).—The Stink-Bug (*Acrosternum marginatum* Say) is present sometimes in great numbers. It attacks several garden crops as well as fruit and cotton. In this family, however, although about twenty-five species have been taken, no great number on any particular weed has been noted.

Homoptera (*Cercopidæ*).—Only two species of Cercopidæ have been taken in the county. One of these is very abundant at times on Bitter-weed. It may be that these insects cannot stand the period of summer drought, especially since the grass covering has been practically destroyed.

(*Membracidæ*).—About thirty species of this family have been collected. They are most abundant both as to species and as to individuals in those old fields which have reached the stage where they contain the greatest number of weeds and grasses, especially on the edge of thickets.

(*Fulgoridæ*).—Something over thirty species of this family have been taken. These include members of the following sub-families: Fulgorinæ, Dictyophorinæ, Acanaloniinæ, Cixiinæ, Flatinæ, and Delphacinæ. Fulgoridæ are very generally distributed throughout the area. Members of the last named sub-family are especially abundant in grassed-over fields.

Coleoptera (*Cicindelidæ*).—This family has almost certainly increased in number of individuals since settlement. They are most abundant on the beaches of the Brazos River and along the sandy shores of the branches. This habitat has been extended as noted under Ant-Lions. Some species, especially *Cicindella reticulatera* occur in great numbers along the old roads and in old fields in eroded areas. Twenty-two species have been taken in the county. While there may not be any

more species at present than formerly, there are probably many more individuals owing to the greater extent of larval habitats.

(*Carabidæ*).—What has been said of the Tiger Beetles is true also of the Ground Beetles. Many species are found in great numbers, especially in abandoned fields of the Croton-Bitterweed-Broomweed stage. Some species are most commonly found in the Post Oak Woods.

(*Scarabaeidæ*).—Both scavenger and leaf-feeding members of this family are found in considerable numbers. It seems though, with the reduction of sod-land, certain species must have been reduced in numbers. On the other hand, there is no doubt that the scavengers are more plentiful than formerly.

PREDACIOUS AND PARASITIC INSECTS.

One of the features of the insect fauna of the area is the great number of parasitic and predacious insects. Comparisons with other parts of the country could not be made, but more species of insects of these types are found in old fields than in native grasslands. This probably points to an increase in number of individuals since settlement.

INSECTS OF OLD FIELDS.

Observations in various types of old fields show a definite seasonal succession. During the winter and spring months the Cicadellidæ are most numerous in species. As the weather gets warmer many other species of Hemiptera and Homoptera appear. A "peak" of the spring insect complex is reached about June 1. At this point the sucking insects disappear to a great extent and the Orthoptera, especially the Locustidæ, become increasingly numerous. By the middle of September they form the dominant group. This seasonal succession is most evident in old fields which have reached the stage where the greatest number of annuals are present.

An interesting accompaniment of this seasonal succession is the gradual increase of predacious and parasitic forms to a "peak" which is reached about the first of October.

In native grassland seasonal succession is not much in evidence. In fact, it seems that the Hemiptera and Homoptera

increase throughout the season, reaching a climax at about the same time as the Orthoptera.

An ecological succession may also be observed in old fields. In the youngest stage the insect fauna is scanty at all seasons of the year except for a few forms which may appear in great numbers of individuals. The Locustidæ often lay their eggs in such places, and the nymphs invade nearby cotton fields. Cicadellidæ and Carabidæ are abundant in late summer. If crotons are present there may be myriads of Cotton Flea Hoppers. With the coming of more annuals, the insect complex increases until a climax is reached with the start of the grasses. In old fields which have been taken by grasses the insect fauna is comparatively poor. This is especially true if Aristida sp. is the grass. The scanty insect fauna of such a field is as striking as the variety of insects found in old fields just before grasses gain the ascendancy. It would seem reasonable to conclude that settlement, by wiping out much of the original flora and introducing a new and more varied one, has at least changed the original insect fauna as to numbers of individuals of many species.

INSECTS OF POST OAK WOODS.

The insect fauna of the Post Oak Woods bears a curious resemblance to that of the old fields, especially that of the old fields which are nearly taken by grasses. The difference lies mostly in lessened numbers of individuals if those forms which feed on trees and shrubs be ignored. One interesting fact is that while the fields may be mostly bare of insect life in January and February, certain insects, especially Orthoptera, Coleoptera, and Hemiptera, may be found in the woods throughout the winter. The similarity of the insect complex may be due to the fact that many of the plants common in the fields may still be found in the woods. In other words, the Post Oak Woods are recent invaders of the grasslands, and true forest conditions have not yet developed.

CICADELLIDÆ OF BRAZOS COUNTY.

In the following list of Cicadellidæ are included all the records of Texas species in the writer's collection. This is not offered as a complete list of Brazos County species, for, because of the peculiar distribution of leafhoppers in the area, as will be pointed out later, new records are being added at frequent intervals. It is believed to be inclusive enough, however, to show the characteristics of the leafhopper fauna. No citations are given prior to the Van Duzee catalog.

Agallia novella (Say), Carpet Grass in dense growth, Navasota Bottom. May, June, July.

Agallia constricta Van D., Most abundant in old fields which have reached the grass stage, but still contain many weeds. Alfalfa, Bermuda Grass, Burr Clover. April, May, June, August, November.

Agallia sanguinolenta (Prov.), All old fields except driest, also on Alfalfa and Bermuda Grass; not abundant. Throughout year.

Agallia uhleri Van D., One of the few species taken in Aristida fields. Old fields in general. May, June.

Agallia gillettei O. and B., Not known. Collected by H. C. Yingling. October.

Agallia cinerea O. and B., Bermuda Grass. Only one individual taken. August.

Idiocerus nervatus Van D., Willow. April. Collected by H. G. Johnston.

Macropsis viridis (Fitch), Willow at edge of tanks. April, May, June.

Bythoscopus robustus (Uhl.), Honey Locust. Frequently taken from coarse weeds. Throughout year.

Oncometopia undata (Fab.), Cotton, coarse weeds in river bottom. Willow. April, July, September.

Oncometopia lateralis (Fab.), Similar to O. undata, also on Alfalfa. Throughout year.

Homalodisca triquetra (Fab.), Cotton, coarse weeds, Bottom Land. June to September.

Aulacizes irrorata (Fab.), Cotton, coarse weeds, Willow. Bottom Land. April to October.

Kolla bifida (Say), Bermuda Grass. Most abundant in Bottom Land. June to August.

Kolla hartii (Ball), Old fields in grass. Aristida sp. Throughout year.

Graphocephala versuta (Say), Alfalfa. Bottom Land shrubs and vines. Throughout year.

Draeculacephala floridana Ball, Edge of Salt Lagoons near Point Isabel, Texas. Occurs on Monanthochloe littoris and possibly on the associated Salicornia ambigua. Not found in Brazos County. January, February.

Draeculacephala balli Van D., Bermuda Grass, in pine woods, Beaumont, Texas. December.

Draeculacephala acuta (Walk.), Grass, especially Bermuda. May to July.

Draeculacephala bradleyi Van D., Grass on lawn. One specimen taken. December.

Draeculacephala angulifora (Walk.), Mixed grass and weeds. Taken by H. J. Reinhard. September.

Draeculacephala mollipes (Say), Grass. June to October.

Draeculacephala minor (Walk.), Grass. May to September.

Draeculacephala noveboracensis (Fitch), Grass; only one taken. June.

Draeculacephala sagittifera (Uhl.), Bermuda Grass, Gulf Coastal Prairie. At Angleton and Freeport extremely abundant on this grass. One specimen in Brazos County. Occurs also in Pine Woods at Beaumont, Texas. Throughout year.

Draeculacephala reticulata (Sign.), Bermuda Grass, Oats, Burr Clover, Alfalfa, Old fields. Throughout year.

Gypona octolineata (Say), Old fields where weeds and grass are rankest. Native grassland. May, June, July.

Gypona melanota Spangb., Mixed grasses in old fields. June.

Gypona angulata Spangb., Weeds in old fields. September.

Gypona scarlatina Fitch, Collector unknown; not taken by writer. May and November (?) 1904.

Gypona miliaris Stal., Mixed herbs and grasses, low places in old fields. Native grassland. August, September, October.

Gypona resima Fowl., Mixed herbs and grasses; low places in old fields. May, June, July.

Xerophloea viridis (Fab.), In grasses and herbs along south side of woods. Sometimes within woods. Aristida sp., Native grassland. May to November.

Xerophloea major Baker, As in X. viridis and also in alfalfa, Brazos Bottoms, Aristida sp. Native grassland. May to November.

Dorycephalus platyrhynchus Osb., Old fields, mixed grass and herbs in dry localities. September.

Spangbergiella mexicana Bak., Collected from Post Oak by T. P. Remy; one specimen taken. January.

Parabolocratus flavidus Sign., Mixed grass and herbs, old fields, low places. Native grassland. May to September.

Mesamia straminea (Osb.), Collected by H. C. Yingling. September, October.

Mesamia palliolata (Ball), Wild sunflower, Dallas. Not taken in Brazos County. April.

Scaphoidus sanctus (Say), Old field weeds. June.

Scaphoidus immistus (Say), Old fields, weeds. June.

Platymetopius cinereus O. and B., Grass in low places in old fields. Also grass in pine woods. Beaumont, Texas. Native grassland. Throughout year.

Platymetopius frontalis Van D., Native grassland. May, June, July.

Platymetopius loricatus Van D., Has been swept from grasses and also from cedar and Crataegus. Native grassland. March to November.

Platymetopius magdalensis Prov., Grass in thick growth. September.

Deltocephalus inflatus O. and B., Grass in low places. Throughout year.

Deltocephalus weedi Van D., Old fields of grass and low-growing herbs. Native grassland. Throughout year.

Deltocephalus obtectus O. and B., Old fields of grass and weeds. Native grassland. Throughout year

Deltocephalus compactus O. and B., As D. weedi. Throughout year.

Deltocephalus flavicosta Stal., Grass in pine woods, Beaumont, Texas. January.

Deltocephalus debilis Uhl., Low thick grass. September.

Deltocephalus pyrops Crumb.; Crumb. Ann Ent. Soc. Amer., viii, p. 191, 1915. Platymetopius pyrops Van Duzee, Cat. Hemip. N. A. P. 365, 1917. Acurhinus pyrops Osborn, Ohio Jour. Sci., xx, p 159, 1920. The above synonomy is taken from "A Monographic Study of the North American Species of the Genus, Deltocephalus," by Dwight Moore DeLong, Ohio State University, University studies, vol. II, No. 13, contributions in Zoology and Entomology, No. 3.

Swept from mixture of weeds and grass. September.

Aconura atropuncta (Gill.).

Euscelis obscurinervis (Stal.); Jassus (Thamnotettix) obscurinervis Stal., Eugenies Resa, Ins. Hemipt., 1858, p. 293. Cicadula exitiosa Uhler, Am. Entom., Vol. III, 1880, p. 72. Euscelis exitiosa Van Duzee, Catalog Hemip. North of Mexico, 1917, p. 655. Euscelis obscurinervis, Osborn, Ann. of the Carnegie Museum, Vol. XV, p. 412, 1924. The above synonomy is taken from "The Leafhoppers of Ohio," by Herbert Osborn, Ohio Biological Survey, Bull. 14, Vol. III, No. 4, p. 291, Sept., 1928.

Bermuda Grass, Oats, Burr Clover, Alfalfa, thick short grass, especially in low places. Throughout year.

Euscelis striolus (Fall), Taken in sweepings from cotton, not taken in Brazos County. August.

Euscelis bicolor (Van D.), Oats, old fields, Bermuda Grass, but not as extensively as E. exitiosus. Throughout year.

Euscelis obtutus (Van D.), Short thick grass, mostly taken in Post oak woods. April, September.

Euscelis sp., Throughout year. Frequently taken in winter on warm days.

Euscelis sp., Short grass in a low place in old field. October. One specimen only taken.

Eutettix pictus Van D., From low shrubs in Pine woods. Beaumont, Texas. December.

Eutettix seminudus (Say), Swept from cotton in Falls County. August.

Eutettix cinctus O and B., Old field, weeds and grasses. June.

Eutettix strobi (Fitch), Weeds in old field. August and September.

Phlepsius spatulatus Van D., Navasota River Bottom, tangled dead weeds and small shrubs. December.

Phlepsius excultus (Uhl.), Weeds at edge of woods. May, June, July.

Phlepsius distinctus Lathrop, Grass and dewberry vines at edge of cultivated fields. Throughout year.

Phlepsius pulchripennis Baker, Weeds in old fields. June.

Phlepsius turpiculus Ball, Grass and vines. April to October. Taken also in Waller County, and at Beaumont in Pine woods.

Phlepsius irroratus (Say), Grasses. June to September.

Phlepsius collitus Ball, Grass and weeds in old fields. June.

Acinopterus acuminatus Van D., Taken both in old fields and in Post-oak woods on grass and weeds. Alfalfa. Throughout year.

Thamnotettix fitchii Van D., Grass in low places in old fields. October.

Thamnotettix nigrifrons (Forbes), Bermuda Grass. Widely distributed in many other grasses, Oats, Native grassland. Throughout year.

Thamnotettix colonus (Uhl.), Swept from Oats, Bermuda Grass, Carpet Grass. Seems to prefer short thick-growing grass. Native grassland. Throughout year.

Chlorotettix spatulatus O. and B., Grass and weeds in old fields. May to October.

Chrolotettix viridius Van D., Grasses and weeds in old fields, also in Post oak woods. Native grassland. June to September.

Chlorotettix galbanatus Van D.. Grass and weeds in old fields. April to June.

Neocoelidia tumidifrons G. and B., Swept from grass and weeds. August and September.

Tinobregmus pallidus Osb., Swept from weeds in old fields. May to September.

Cicadula sexnotata (Fall.), Found on grass, both in fields and woods; also on alfalfa and oats. Throughout year.

Balclutha impicta (Van D.), Oats and grass. September and October.

Eugnathodus abdominalis (Van D.), Bermuda grass. Old fields, Aristida. March to December.

Dikraneura abnormis (Walsh), On grass both in old fields and in Post-oak woods. Throughout year.

Dikraneura fieberi (Loew), On grass in old fields and Post-oak woods. May to October.

Empoasca fabae (Harr.), Beets, Beans. January (?) to May.

Empoasca sp., Swept from cotton in Falls County. August.

Erythroneura comes (Say), Wild grape, shrubs, and vines. Throughout year.

Relation of Leafhopper Fauna of Brazos County to That of the Rest of North America.

In the preceding list but nine species are recorded by Van Duzee (9) as occurring only west of the Mississippi River. About eighty species are recorded as occurring east of the Mississippi River. Fifty-one species of these are recorded as occurring in Florida. Turning now to Lathrop's list of South Carolina species (3) we find fifty-seven of the Brazos County list recorded. Laying aside the question of the origin, the leafhopper fauna of Brazos County appears from the above records to be a part of that fauna whose center of distribution is the Mississippi Valley. The term "center of distribution" is used as defined by Transeau (8) in relation to plants, that is, as not implying that the Cicadellidæ necessarily spread from the Mississippi Valley, but that the complex of ecological factors most favorable to the development of an extensive leafhopper fauna, both as to number of species and as to number of individuals, is located there.

When first starting to collect Cicadellidæ in this region, the writer expected to find many typically southwestern forms. That this has not been the case has been shown above. After all, when we consider the vegetation of the county and its relation to the eastern forests and to the prairie, it seems reasonable that the insect life would show more eastern than typically southwestern forms.

Studies in the Present Distribution of Leafhoppers in the County.

In the attempt to gain as comprehensive an idea as possible of the leafhopper fauna of the county, the leafhopper complex of each of the following habitats has been studied:

1. Native grassland
2. Old field.
3. Aristida field.
4. Bermuda grass
5. Oats.
6. Alfalfa.
7. Post-oak wood grassland.
8. Leafhoppers of woody plants.

This is an example of static or "pigeon-hole" classification of habitats. It seems about the only one possible considering the disturbed condition of the vegetation. While it would probably be possible for a plant ecologist to work out a genetic classification of the vegetation of the county, some of the plant

associations would not be large enough to be significant as insect habitats.

In the discussion of the leafhopper complex of the above habitats, no attempt has been made to connect up each species of leafhopper with some particular habitat. The attempt has rather been made to give the conspicuous features of the leafhopper complex of each habitat and to show its relation to that of other habitats.

NATIVE GRASSLAND.

This association is of such limited extent that the leafhopper complex peculiar to it must have been considerably modified. One characteristic is noticeable, namely, the evenness of distribution of species both throughout the field and throughout the season. This has been found to be true of no other habitat with the exception of the Post-oak wood grassland. This can be explained by the fact that in these habitats the leafhoppers are not so exposed to the extremes of heat, light, and moisture. In the native grassland the grasses form a thick covering so that conditions are more equable throughout the year and throughout the field.

Leafhoppers of the native grassland: *Draeculacephala mollipes; D. minor; Gypona octolineata; G. miliaris; Xerophloea viridis; X. major; Platymetopius cinerius; P. frontalis; Deltocephalus weedi; D. obtectus; D. compactus; Euscelis bicolor; Phlepsius irroratus; Thamnotettix nigrifrons; T. colonus; Chlorotettix viridius; Eugnathodus abdominalis.*

At nearly any time from April to November any of these species may be taken in native grassland. The two species of Draeculacephala are usually the most numerous. *T. nigrifrons* is also abundant. *E. abdominalis* is very evenly distributed throughout the field. None of these species are confined to this habitat. All have been taken in old fields and on weeds and grass in Post-oak woods. In the old fields, however, their distribution is very different.

A number of other species have been taken in these fields. *D. reticulata* and *E. obscurinervis* are fairly common, but have never been found in such numbers as in Bermuda grass or oats or in patches of grass in old fields.

OLD FIELDS.

An old field is a very different habitat from the preceding. The following discussion applies to a field which has reached the stage where it has the maximum number of species of grasses and annuals referred to in the first part of this paper; in other words, just before the grass has become dominant. The grass is of a number of species, but the Aristidas appear early upon the drier situations, while Bermuda grass frequently forms almost pure stands in lower, moister places.

Leafhoppers of old fields: *Agallia constricta; A. uhleri; Kolla hartii; Draeculacephala acuta; D. mollipes; D. minor; D. reticulata; Gypona octolineata; G. miliaris; G. resima; Xerophloea viridis; X. major; Scaphoidus sanctus; S. immistus; Platymetopius cinereus; P. frontalis; Deltocephalus inflatus; D. weedi; D. obtectus; D. compactus; Euscelis obscurinervis; E. bicolor; E. obtulus; Eutettix cinctus; E. strobi; Phlepsius distinctus; P. pulchripennis; P. turpiculus; P. irroratus; P. collitus; Acinopterus acuminatus; Thamnotettix fitchi; T. nigrifrons; T. colonus; Chlorotettix spatulatus; C. viridius; C. galbanatus; Tenobregmus pallidus; Cicadula sexnotata; Eugnathodus abdominalis; Dikraneura abnormis.*

A number of other species have been taken, but these are the species most in evidence.

The seasonal distribution is interesting. Beginning about the first of February, but varying from year to year according to temperature and moisture, there is a gradual increase in the number of individuals and of species as the season advances. *D. reticulata*, *E. obscurinervis*, and *T. colonus* are present all winter in good numbers. They show the first increase in numbers and are followed by *D. mollipes*, *G. octolineata*, *E. bicolor*, *T. nigrifrons*, *C. viridius* and *C. sexnotata*. These species do not always follow in the order given. Moisture is undoubtedly the controlling factor as it affects their favored food plant. In following an old field through a year the effect of moisture upon the leafhopper complex can easily be observed. In the spring the distribution of species throughout the field is comparable to the distribution in a field of native grass as regards species. Always, however, there are places in an old field where individuals are extremely numerous. As the season advances there is a gradual drying up of the higher

places in the old field and a corresponding decrease in leafhoppers until by the middle of July in average years these places will be devoid of leafhoppers. They may still be found in the lower places in the old field where the grass covering is densest.

It should not be inferred that there is a migration from the drier localities to the more moist. This has never been observed, nor does there appear to be any increase of leafhoppers in the moister places as the season advances. These places show a marked uniformity of species and number of individuals throughout the year as compared with the rest of the old field. There is, however, a migration from the more favored spots to the rest of the field as soon as rains make them suitable for leafhopper existence. That this is true is shown by the presence of both nymphs and adults in the moister places and the gradual appearance of adults only in the drier places following improved moisture conditions.

ARISTIDA FIELDS.

Many of the old fields of the county have been taken by these grasses. They gradually replace the annuals and are probably the climax vegetation on certain soils. Especially noticeable in late summer and early autumn are the fields where *Aristida purpurascens* is dominant. Many of the annuals are in evidence in the spring, but they are greatly reduced in number of individuals.

Leafhoppers of Aristida fields: Only seven species have been taken in pure stands of Aristida, *Agallia uhleri; Kolla hartii; Xerophloea viridis; X. major; Thamnotettix fitchii,* (one specimen); *Eugnathodus abdominalis; Dikraneura abnormis.* None of these species have ever been taken abundantly enough to avoid the suspicion that they are accidentally present. *E. abdominalis* has been found to be the most numerous species in this habitat.

BERMUDA GRASS.

This grass was introduced into Texas in the 1870's. It is now widely distributed both in the bottoms and upon the uplands. It spreads wherever the native grasses have been thinned out and there are opportunities for its runners to make their insidious advance. This grass can be found green in

sheltered places throughout the winter. It is drought-resistant and remains green all summer except in the very driest places. These two facts, together with its wide distribution, make it of the first importance as a food plant for many insects. Hemiptera and Homoptera are especially abundant on it at times. This is particularly true of the Cicadellidæ.

Leafhoppers of Bermuda grass: *Agallia constricta; Oncometopia lateralis; Kolla hartii; K. bifida; Draeculacephala mollipes; D. reticulata; D. angulifera; D. Acuta; D. minor; Gypona octoliniata; Xerophloea viridis; X. major; Platymetopius frontalis; Thamnotettix nigrifrons; Euscelis obscurinervis; Phlepsius collitus; P. irroratus; P. distinctus; Acinopterus acuminatus; Chlorotettix viridis; Cicadula sexnotata; Eugnathodus abdominalis.* A number of other species might be named, but the above mentioned are the most characteristic.

Several of these leafhoppers, i.e. *Draeculacephala mollipes, D. reticula, Thamnotettix nigrifrons, Euscelis obscurinervis, Phlepsius irroratus,* and *Cicadula sexnotata* are well-known to be pests of grains and grasses. *Eugnathodus abdominalis* is very abundant on Bermuda grass at times. *D. reticulata* and *E. obscurinervis* fairly swarm upon this grass. Without doubt it supports the greatest number of individuals, if not the greatest number of species, of any leafhopper food plant in the county. The number of *D. sagitifera* on Bermuda grass at Freeport, Texas, is amazing. This constitutes the heaviest infestation of leafhoppers yet seen by the author on any plant. Only one specimen of the species, however, has been taken in Brazos County.

One characteristic of the Bermuda grass habitat is the many small parasitic Hymenoptera which find shelter in it throughout the winter. Whether they are parasites of Cicadellidæ or not has not been determined, but certainly leafhoppers are the most numerous insects present. In fact, they are frequently the only insects taken in the bag after vigorous sweeping with the exception of the parasitic Hymenoptera mentioned.

OATS.

This crop is planted in Brazos County about the middle of October or before if there has been sufficient rainfall following the usual summer drought. It is generally used for grazing.

From the time the oats come up in the fall until about the first of May they are attacked by a number of species of Cicadellidæ. In fact, the same species listed as characteristic of the Bermuda grass have been taken from oats. Their appearance upon oats, however, is quite different from that on Bermuda grass. This is one instance in which a definite migration from one habitat to another can be checked. About the time the oats are about three inches high *Euscelis obscurinervis* will be found. Then Draeculacephala begin to appear, closely followed by *Cicadula sexnotata* and *Thamnotettix nigrifrons*. These will be abundant in the oats all winter. Even twenty-four hours of south wind and of sunshine, following a norther with a drop of 30 degrees F. or more, serve to bring them out in myriads. About the first of February several other species appear, increasing rapidly in numbers. *Agallia uhleri*, *Eucelis bifida*, *Draeculacephala mollipes* and *D. minor*, *Phlepsius irroratus*, *Chlorotettix viridius*, and sometimes *Eugnathodus abdominalis* are present in considerable numbers. All of these may be taken on the Bermuda grass which is almost always near. On the grass, too, many nymphs may be taken at nearly all times. Nymphs are quite scarce upon the oats, especially at any considerable distance from the grass.

Euscelis obscurinervis is the most abundant form on the oats. They are followed by *Draeculacephala reticulata* and the *Cicadula sexnotata*. These three species are nearly always present in greater or less numbers upon oats throughout the season.

ALFALFA.

This crop is grown in Brazos County only in the Brazos River Bottom. It forms a dense covering in this situation and it is attacked by numerous species of leafhoppers throughout the year. The leafhoppers, however, are most abundant in late fall and early spring.

The leafhopper perhaps most evenly distributed through a year period is *Empoasca fabæ*. This, too, is probably the most abundant, though *Agallia constricta* is very plentiful at times, especially in the late fall. *A. sanguinolenta* has not been taken abundantly, but it is nearly always found and is of particularly even distribution over the field. *Oncometopia lateralis* is common on alfalfa and sometimes is the most abundant species,

especially in the spring during March and April. *Graphocephala versuta* is found frequently, but nearly always at the edge of the field near weeds and vines. *Acinopterus acuminatus* is generally distributed throughout the fields. *Chlorotettix viridius* occurs frequently. *Eugnathodus abdominalis* is abundant at times and in restricted areas.

Nymphs of nearly all these species are to be found, especially in the spring, but never in such numbers as are to be found upon nearby Bermuda grass. This is almost certain proof of a constant migration from this grass to alfalfa.

One peculiarity of the leafhopper complex is that though *E. obscurinervis* and *D. reticulata* and *D. mollipes* are taken, they are never so abundant as they are upon Bermuda grass and oats on the upland.

POST-OAK WOODS GRASSLAND.

This grassland consists to a considerable extent of the same grasses found in the open fields. *Andropogon furcatus, A. scoparius, A. saccharoides, Aristida sp.*, and many others are found scattered throughout the wooded area. The same annuals, too, are present. Even the crotons are found in spots. None of the annuals, however, assume the dominance common in old fields. It is probable as before stated that true forest conditions have not yet developed over a great deal of the wooded area in the county.

Leafhoppers of post-oak woods grassland: *Draeculacephala mollipes; D. minor; Xerophloea viridis; X. major; Platymetopius cinereus; Deltocephalus weedi; D. compactus; Thamnotettix colonus; Eugnathodus abdominalis; Phlepsius irroratus.*

This complex resembles that of the native grassland in species content and in the quite even distribution. *D. recticulata, E. obscurinervis* have not been taken, however, in the Post-oak woods grassland. Neither have any of the species named in the complex ever been taken in any considerable numbers. This complex probably represents a relic of the former leafhopper fauna of the county.

WOODY PLANTS.

Only eight species of leafhoppers have been taken from woody plants, such as shrubs, trees, and vines. As the forest grows more scanty toward its western limit, the species inhabit-

ing the woody plants peculiar to the forest will grow less. Even though the favorite food plant may be present, it may be in such scattered numbers that the factors of moisture, heat, and light may be unsuited to the insect. The texture of leaves may grow more tough and resistant to insect attack due to the arid conditions. The chances, too, of migration become less as the host plant becomes less frequent.

Leafhoppers of woody plants: *Idiocernus nervatus* (willow); *Macropsis viridis* (willow); *Bythoscopus robustus* (Honey locust); *Oncometopia undata* (willow, poplar, cottonwood, many shrubs, cotton, and vines); *O. lateralis* (as in the case of the preceding); *Aulacizes irrorata* (as in the preceding); *Graphocephala versuta* (as in the preceding); *Erythroneura comes* (Cretagus, youpon).

Original Character of the Leafhopper Fauna.

Whatever the character of the vegetation of Brazos County before settlement, it undoubtedly presented a more uniform type of plant distribution than at present. That the grasses predominated is certain. There were many annuals mostly in evidence in the spring and early summer. These, however, did not occur as pure stands of annuals, that is, where one annual followed another throughout the growing season. This points to a more even distribution of leafhoppers than occurs at present. That this is true is shown by the leafhopper complex of a field of native grasses. By the term native grasses is meant a field which has never been plowed or overgrazed. The writer finds it impossible to point to any one group of leafhoppers as probably dominant before settlement, unless the leafhoppers of these fields are representative of the original complex. Probably there was no particularly dominant group but an even distribution of species and individuals throughout the area. Of course, there was a gradual elimination of certain species as the drier situations were approached.

Influence of Settlement Upon Original Leafhopper Fauna.

Settlement affected the vegetation through grazing and through agriculture. At first it is not likely that grazing had much effect, but as more and more of the land was fenced and more cattle concentrated on any given area, the palatable

grasses were destroyed and old field vegetation took its place. Plowing destroyed the original vegetation at once, and when, after a few years devoted to growing cotton, the land was abandoned, the annuals from the old fields speedily came in. In the place of the former grassland appear great areas in which seasonal succession of annuals takes place.

We have discussed the probable original evenness of the leafhopper distribution. Agriculture undoubtedly broke up any such evenness. In a drive from College Station south to Navasota, a distance of twenty-six miles, all the habitats discussed previously, with the exception of native grassland, may be seen. Even this is approximated along the railway right-of-ways. It is easy to demonstrate the difference between the leafhopper complexes of these various habitats at any given time of year. It is also easy to see that these habitats are the result of settlement. Habitats which may be separated by only so much as a fence are totally different from a floristic and faunistic point of view. This difference did not exist before settlement.

Certain species have increased as to number of individuals because of the changed conditions. *Euscelis obscurinervis* was probably one of these, as were also *Draeculacephala reticulata* and *Cicadula sexnotata*. This is thought to be true because of the increase in areas of short grass such as Bermuda and of other grasses kept short by grazing. In such places and in oats these species are extremely abundant.

On the other hand, it seems probable that many species of Phlepsius, Gypona, Platymetopius, and Deltocephalus have decreased in number of individuals. At the present time these are widely distributed, though but one or two species and few individuals of these being taken at any one place. They are still abundant but in nothing like the numbers common to the species discussed in the preceding paragraph.

Another way in which agriculture has affected the leafhopper fauna is in the decrease of suitable breeding places. Formerly, under the conditions of even distribution of grasses, it is probable that leafhoppers bred over the whole region. Now, if collecting is carried out over an old field at regular intervals, it is readily seen that breeding is restricted to certain areas. These areas are usually the lower places in the field as it is there only that

nymphs are taken. There still remain, however, a sufficient number of breeding places that there has most likely been no decrease of species within the area.

SUMMARY.

Brazos County, Texas, while located in what is usually referred to as the Post-oak Region, was at a former time, nevertheless, dominated by grasses. The grasses occurred in almost pure stands except that in the spring there were many flowering annuals.

Settlement through overgrazing and agriculture broke up the original flora. In this way many annuals which once occurred scattered throughout the region were allowed to assume dominance. Thus was brought in typical old field vegetation. The breaking up of the original flora affected also the insect fauna in that it made conditions favorable for the increase of certain species.

The Cicadellidæ of the county are a part of the leafhopper fauna of the Eastern United States with the addition of a few southwestern species.

There are at the present time various habitats each with a characteristic leafhopper complex.

The Cicadellidæ were formerly distributed evenly over the area.

Agriculture has broken up the original evenness of distribution. It has also introduced Bermuda grass and oats, and it has permitted certain species to increase enormously in number of individuals. By destroying the original grassland, it has at the same time decreased the number of individuals of certain other species. It probably has not changed the original number of species in the area.

LITERATURE CITED.

(1) **Bray, William L.** 1906. Distribution and Adaptation of the Vegetation of Texas. Bul. of the University of Texas, No. 82, Scientific Series, No. 10.

(2) **De Long, Dwight M.** 1916. Tenn. St. Bd. Ent., Bul. 17.

(3) **Lathrop, Frank H.** 1919. The Cicadellidae or Leafhoppers of South Carolina. So. Car. Agr. Exp. Sta. Bul. 199.

(4) **Little, V. A.** 1926. Notes on the Acrididae of Brazos County, Texas. Ent. News, Vol. XXXVII, p. 316.

(5) **Osborn, Herbert.** 1912. Leafhoppers Affecting Cereals, Grasses, and Forage Crops. U. S. D. A. Bu. Ent. Bul. 108.

(6) **Reinhard, H. J.** 1928. Hibernation of the Cotton Flea Hopper. Texas Agri. Exp. Sta. Bul. 377.

(7) **Shantz, H. L.** and **Zon, Raphael.** Map Showing Natural Vegetation of United States. U. S. D. A., Bu. Pl. Ind. and For. Ser.

(8) **Transeau, E. N.** 1905. Forest Centers of Eastern North America.

(9) **Van Duzee, Edward P.** 1917. Catalog of the Hemiptera of America North of Mexico.

(10) **Webster, F. M.** 1903. The Diffusion of Insects in North America. Psyche, X, pp. 47-58.

EXPLANATION OF PLATES.

Plate I.

Fig. 1. Original Post-Oak Forest.

Fig. 2. Present Post-Oak Forest which has practically replaced original type.

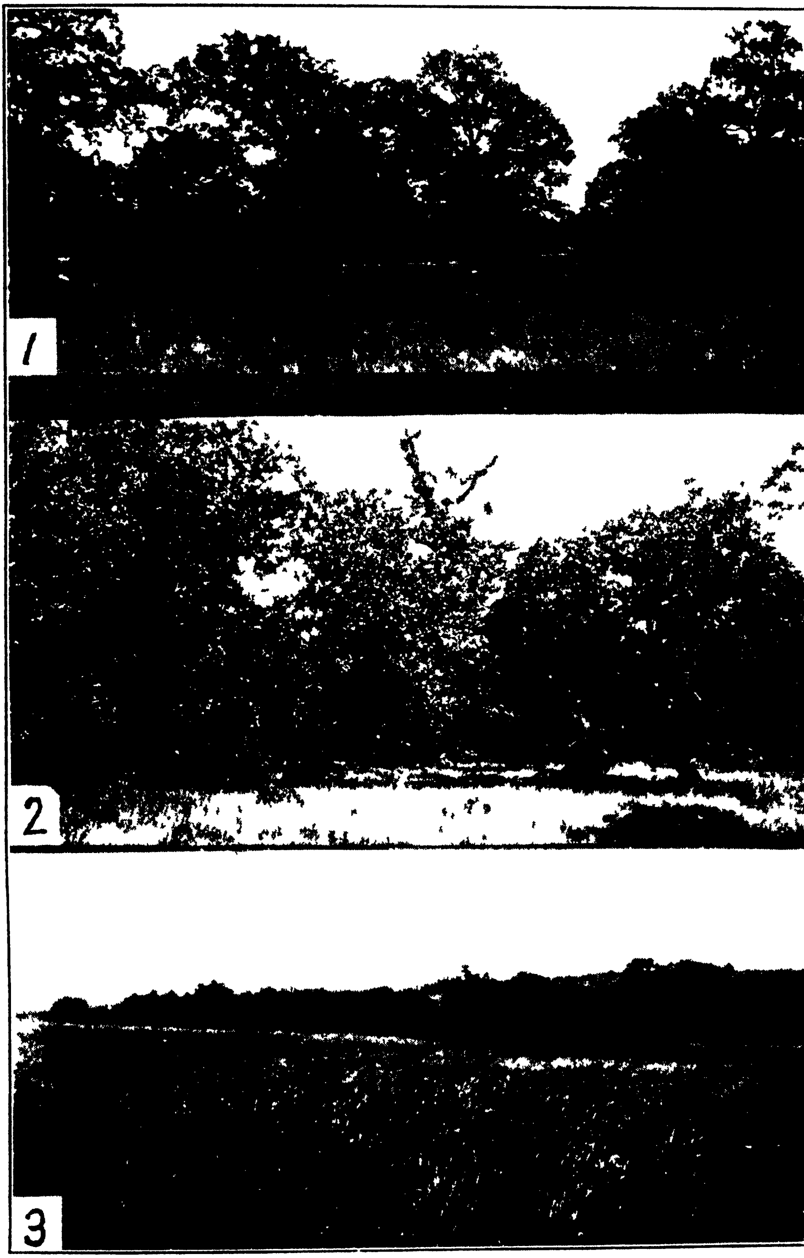
Fig. 3. Prairie formation on black land. Principal grasses, *Andropogon furcatus* and *A. scoparius*.

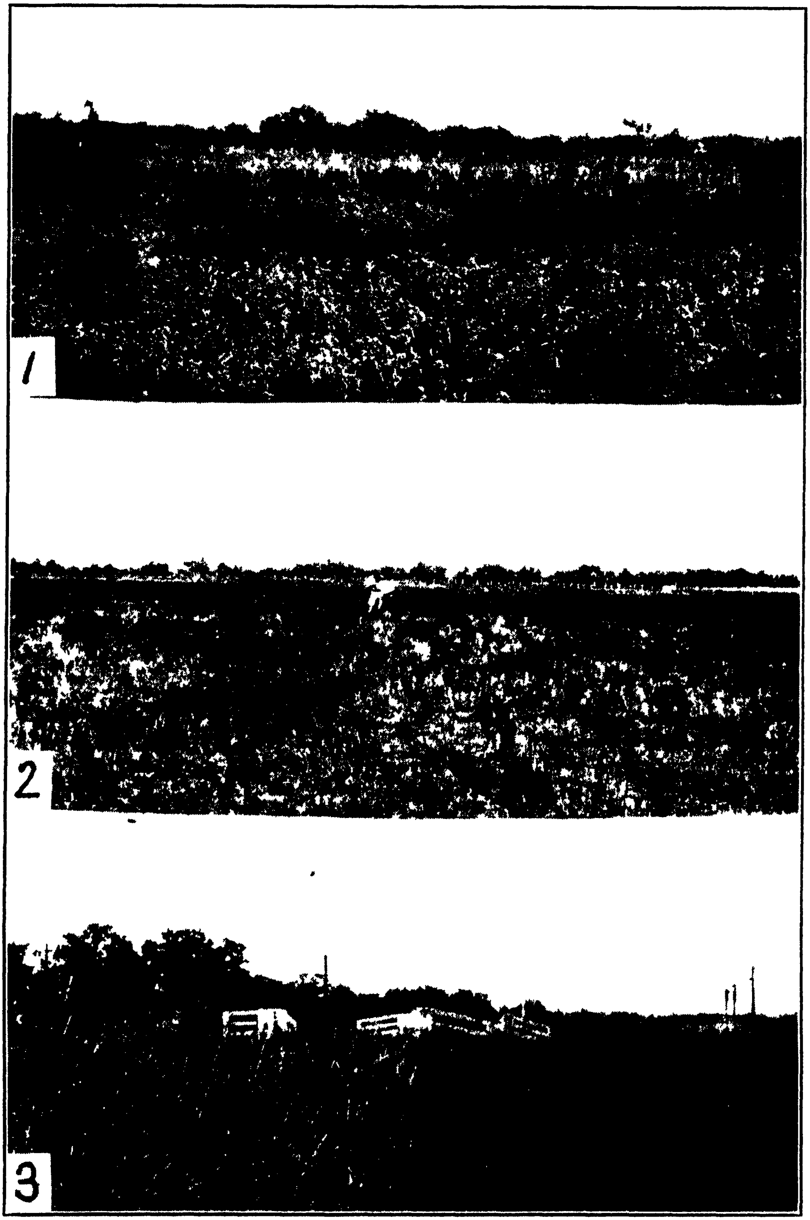
Plate II.

Fig. 1. Old field. Croton Weed.

Fig. 2. Old field. Bitterweed.

Fig. 3. *Andropogon scoparius* and *A. saccharoides* along railway right-of-way.


1
2
3


1
2
3

STUDIES IN THE ECOLOGY OF FOREST COLEOPTERA.*

Seral and Seasonal Succession of Coleoptera in the Chicago Area, With Observations on Certain Phases of Hibernation and Aggregation.

ORLANDO PARK.
Whitman Laboratory, University of Chicago.

The region in the vicinity of Chicago, Illinois has been described previously by Salisbury and Alden (1899), Cowles (1901), Shelford (1913), and more recently by Fryxell (1927), among others. In general, Cowles noted (p. 8) that this area has "three great vegetation types: the mesophytic upland forests of the morainic clays, the hydrophytic lakes and swamps or mesophytic prairies of the Chicago plain, and the xerophytic forests of the dunes and beaches."

The upland forest sere in the Chicago area was shown to be composed of a number of well-defined plant communities by Cowles (1899, 1901). Such a succession is shown in the sand dune region of northern Indiana, where, beginning with the xerophytic beaches, these areas are captured by pioneer sand-binding herbs and shrubs, eventually forming sandy fore-dunes. The fore-dunes are succeeded by cottonwood associes, which in turn give way to conifer associes. These latter are replaced by black oak associes which mark the end of the sere in many parts of the dunes, but in other areas these pioneer forests are replaced by a mixed oak-elm-hickory sub-climax forest. The ultimate climax of the sere, in this area, is a beech-sugar maple association in the Indiana, and a sugar maple association in the Illinois, sections of the Chicago area.

The work of Cowles has been greatly extended by that of his students. Recently, Graham (1927) found this succession to hold for the fungi. Shelford (1913) found a correlation

*In this series of papers, I wish to acknowledge the aid and criticism of Dr. W. C. Allee, of the University of Chicago; of Mr. J. A. Maxwell, of the Pilcher Arboretum, Joliet, Illinois, and Mr. W. J. Gerhard, Mr. Emil Liljeblad, and Mr A. B. Wolcott, of the Field Museum of Natural History, for many favors, especially the determination and checking of species of beetles.

between plant and animal species in the forest sere and outlined seral or community succession especially with insect material, e.g. *Cicindela* (pp. 218-261). His studies have been extended most recently by Holmquist (1926), so that the biotic character of the upland forest sere is clearly defined for each major community.

In the present study, beginning with April, 1922, and running through December, 1928, 243 field trips have been made in the upland forest sere. For the last six and three-quarter years (81 months), an average of three trips per month has been maintained. Since March, 1926, 168 days have been spent in the field, or an average of 4.9 days per month, so that sufficient time has been spent in the field to obtain the rough outlines of the beetle communities of the area studied. Of the 243 trips, a majority, e.g. 140, were to the dune area studying the pioneer communities of the cottonwood, conifer and black oak; 29 trips were made to the subclimax oak-elm-hickory communities; and 36 trips were taken to the climax maple and beech-maple associations. The time spent in the field was distributed differentially, viz. roughly 7% of the trips were made in the winter months, 31% in the spring, 40% in the summer and 23% in the autumn.

During this time 592 species and varieties of beetles have been observed and some 5000 specimens mounted for determination. This material represents, in round numbers, about 10,000 ecological records. These species have been arranged after the checklist of Leng (1920, 1927), and, thanks to the specialists mentioned, have been determined as accurately as possible. The material had been frequently rechecked by these workers, and checked again by the writer. These species constitute approximately one-third of the total number of species of beetles found in the Chicago area, and have been incorporated elsewhere into an ecological and taxonomic list, together with the available data on locality range, seasonal range, habitat niche, and hibernation data.*

---

*Park, O. "Ecological Check-list of the Coleoptera of the Chicago Area," (to be published).

I. Seral Succession in the Chicago Area.

This first section attempts to show that there is a beetle sere corresponding to the upland forest sere in the vicinity of Chicago. Six well-defined communities of beetles were studied:

(1). Those species found associated with the strand of Lake Michigan, e g., the sandy depositing shore, including the lower beach complex and foredunes from Tremont, Indiana, to Waukegan, Illinois

(2). The pioneer cottonwood associes of the Indiana dune region

(3). The pioneer conifer associes of the Indiana dune region and the Illinois dune region

(4) The pioneer oak associes in the Indiana and Illinois dune regions; at Edgebrook, Illinois; at Palos Park, Illinois, and a portion of Glenview, Illinois

(5) The sub-climax oak-elm-hickory-basswood associes at Riverside, New Lennox, Edgebrook, and portions of Palos Park and Glenview (Illinois); the "dune climax" at Ogden Dunes, Indiana, and a part of Tremont, Indiana, with comparative data from the bluffs of the Sangamon river near Springfield, Illinois

(6). The climax forest association at Joliet, Illinois (sugar maple); Michigan City, Indiana (young beech-maple), Smith, Indiana, and Lakeside, Michigan (mature beech-maple).

These are the chief areas studied and a more complete list of localities will be found in the check-list mentioned previously.

In the following table (Table I) the 592 species and varieties are separated into their respective 56 families, and the distribution of each family in the major communities is shown.

In this table the number of species refers to the imago only, and the total number on the left represents those species of Coleoptera collected in the upland forest sere of the Chicago area, in the 81 months in which this survey was made. Obviously, many species are not represented which undoubtedly occur, and many more were collected but the material has not been satisfactorily identified.

TABLE I.

DISTRIBUTION OF SPECIES BY FAMILIES.

FAMILY	TOTAL SPECIES	COTTON-WOOD	CONIFER	BLACK OAK	SUB-CLIMAX	CLIMAX	BEACH COMPLEX
Cicindelidæ	9	1	2	3	1	3	7
Carabidæ	123	5	5	46	43	39	89
Hydrophilidæ	1	1		1		1	1
Leptinidæ	1			1			
Silphidæ	12			4	3	7	3
Orthoperidæ	1				1	1	
Staphylinidæ	34	2	2	6	10	17	13
Pselaphidæ	1			1			
Clavigeridæ	1					1	
Scaphidiidæ	4			1	1	3	
Histeridæ	17	3		6	3	7	11
Lycidæ	1						1
Lampyridæ	4			4	2	1	2
Cantharidæ	10	2		5	7	3	1
Melyridæ	4			3	2		
Cleridæ	7			4	2	1	
Corynetidæ	2	1			1		
Oedemeridæ	1				1		
Mordellidæ	14			9	9	4	
Meloidæ	5		1	3	1	1	1
Pyrochroidæ	1					1	
Pedilidæ	5	2		2	3		2
Anthicidæ	1	1					1
Elateridæ	22	1	6	8	6	9	6
Eucnemidæ	2					2	
Buprestidæ	12	1		7	2	1	3
Helodidæ	2	1		1			
Dermestidæ	3				2		1
Ostomidæ	2				1	2	
Nitidulidæ	12	1		4	6	5	3
Monotomidæ	2			2		1	
Cucujidæ	8		2	6	2	2	
Erotylidæ	9			2	5	5	
Cryptophagidæ	8		1	1	3	8	
Mycetophagidæ	2			1	1	2	
Colydiidæ	3		1	3	2	2	
Mycetaeidæ	1				1	1	
Endomychidæ	2			1	1	1	
Coccinellidæ	23	5	1	13	10	6	18
Alleculidæ	5			4		1	
Tenebrionidæ	11	1		5	3	8	
Melandryidæ	7	1		5	1	3	1
Anobiidæ	1			1			
Lyctidæ	1			1			
Cisidæ	1			1			
Scarabaeidæ	36	6		14	4	12	19
Trogidæ	4			1			3
Lucanidæ	5			1	1	2	3
Passalidæ	1				1	1	
Cerambycidæ	37	3		16	15	6	5
Chrysomelidæ	82	9		42	19	18	35
Mylabridæ	1			1			
Brentidæ	1			1	1		
Platystomidæ	1			1			
Curculionidæ	24	2	1	7	6	3	13
Scolytidæ	2	1	1				

The material in Table I may be conveniently condensed as shown in the following table:

TABLE II

PERCENTAGE OF SPECIES FOUND IN THE MAJOR COMMUNITIES.

COMMUNITY	SPECIES	PERCENTAGE OF OCCURRENCE	FIELD TRIPS
Total for sere	592	100 00%	243
Beach community	242	40 87%	140
Pioneer Cottonwood	50	8 44%	140
Pioneer Conifer	23	3 88%	140
Pioneer Oak	249	42 06%	140
Sub-climax	183	30 91%	29
Climax	192	32 43%	36

From the above tables we find that the pioneer conifer associes has the smallest beetle fauna. Among the deciduous communities, the pioneer cottonwood associes has the fewest species, and the apparent peak comes in the black oak associes. This, however, is probably not true, as a comparison of each community with the number of field trips indicates. On this basis we see that if 140 trips were made to each deciduous community the peak would come in the subclimax, and the communities of beetles, arranged in the order of increasing number of species, would be as follows: cottonwood, black oak, climax, sub-climax This is in accord with Shelford (1913, p. 247) who found the greatest number of species of animals in the sub-climax communities.

Taking the total number of species of beetles for each community, it is interesting to note a differential distribution by species. Such a distribution through the upland forest sere indicates that each community has a well defined beetle fauna, and consequently suggests seral succession.

That such succession exists can be further shown in a number of ways.

SERAL SUCCESSION INDICATED BY INDEX SPECIES.

It is convenient to indicate seral succession by means of a few species, rather than by treatment of each community at length. At least three ecological concepts of index species have been developed with respect to community study:

1. PREDOMINANT SPECIES. This has been recently developed by Shelford and his students, and due to its many categories, requires, presumably, a great amount of data on the ecological interrelationships within a community. This method is not used here as the data gathered are not sufficient, in the writer's opinion, to accurately place the species studied.

2. CHARACTERISTIC SPECIES. We may cite the following species of Coleoptera as characteristic for the major communities studied:

The Beach Complex. —This has been described by Shelford (1913) among others and for our purposes falls into two categories: first, those species inhabiting the sandy areas of the beach and foredunes, merging into the bare sand areas of the cottonwood associes; secondly, the beach drift. The beach drift will only be mentioned here as its treatment logically belongs in another category, viz. that of seasonal succession. The species of beetles inhabiting the bare sand areas of the beaches are generally few in number, are addicted to hiding beneath logs and stones or burrowing in the substratum, and frequently are light in color. They are usually carnivorous. We may mention here the diurnal, predaceous tiger beetles, such as *Cicindela repanda* Dej., *C. cuprascens macra* Lec., and *C. lepida* Dej. treated by Shelford (1913); the nocturnal carabid, *Geopinus incrassatus* (Dej.), which has been observed by Chapman and his colleagues (1926); and the small, pale anthicid, *Amblyderus pallens* (Lec.).

The Pioneer Cottonwood.—We may mention here, as characteristic forms, the cottonwood cerambycid, *Plectrodera scalator* (Fab.); the leaf beetles of the cottonwood and willow foliage, as *Lina lapponica* (Linn), *L. scripta* (Fab.) and *Disonycha quinquevittata* (Say).

The Pioneer Conifer.—More time is needed for a better evaluation of this sand dune community, but we may mention as characteristic the bark beetle, *Ips grandicollis* (Eich.).

The Pioneer Black Oak.—A great many species could be noted here, however a few will suffice, e.g. adults of *Cincindela scutellaris lecontei* Hald., the ground beetle, *Carabus serratus* Say, often taken under sod at the base of *Quercus velutina* during the day, and probably hibernating in the forest floor of this community; the spiderwort leaf beetle, *Lema collaris* Say, and the dogbane leaf beetle, *Chrysochus auratus* (Fab.).

The Subclimax Mesophytic Forest.—Here, for general purposes we can combine the flood-plain silt climax and the oak-elm-hickory upland associes. Again many species could be given, of which we may mention the ground beetle, *Carabus maeander* Fisch., taken about the soft sod at the base of elm, ash or hickory and hibernating *in situ*. *Platynus affinis* (Kby.), and many *Chlaenius*, such as *C. aestivus* Say, roam the floor by night and are found under logs and stones on moist soil during the day usually; often grouped together, and frequently the same carabid species being taken in a certain habitat niche time after time, although other, apparently similar situations are untenanted nearby.

The Climax Associations.—As will be shown at another time, a number of characteristic species occur in the climax communities. Here occur a large majority of mycetophagous Coleoptera and others associated with fungi in varying degrees of complexity. A great many species inhabit these communities during the winter months, also, coming in and occupying hibernacula in the floor. Among those species characteristic of the climax is the green tiger beetle, *Cicindela sexguttata* Fab. which hunts by day, spends the nights under logs or elsewhere on the floor, and hibernates beneath bark, etc., the snail-eating carabid, *Sphaeroderous lecontei* (Dej.), the minute cryptophagid, *Tomarus pulchellus* Lec. of the leafy floor debris, and the tortoise leaf beetles, as *Chirida guttata* (Oliv.), *Metriona bivittata* (Say) and *M. purpurata* (Boh.) which also move into the floor from higher strata at the approach of cold weather.

Thus we have, as might be expected, species which represent each well defined upland forest community. Such species may or may not be abundant, and may occur elsewhere, but to the ecologist, characterize the community as surely as would the dominant vegetation.

3. Unique, or Peculiar Species. Many characteristic species tend to occur in one type of community only, limited by some requirement of food usually, or of reproduction possibly. Thus we may mention the cicindelid, *Cicindela lepida* Dej. of the beach complex, the cerambycid, *Plectrodera scalator* (Fab.) of the cottonwood associes, *Cicindela sexguttata* Fab of more mesophytic floors among many other examples.

Obviously peculiar species may often be characteristic for a community but occasionally are so rare or obscure that they

are seldom seen. Again, it should be recalled that peculiar species are often peculiar to a special food or habitat niche rather than the community as a whole and consequently are introduced into other communities with the transfer of their niche by accident or through economic agencies.

An analysis of the data on 592 species and varieties of Coleoptera gives 22 species as occurring only in the cottonwood associes, 5 species found only in the conifer associes, 131 species restricted to the black oak and oak associes, and 73 species peculiar to the mesophytic climax associations. These figures drawn from a study covering 81 months only suggest the general outlines of the beetle sere. Further study would give additional peculiar species, and also show many of our so-called peculiar forms to be found commonly elsewhere. More time spent on this phase of the survey would probably yield higher numbers of peculiar forms and correct for those whose records are due to chance wandering, and whose proper habitat is elsewhere. This would be especially true for the pioneer conifer associes. It is fully recognized that there are all degrees of distribution between these "peculiar" species and the wide-ranging forms which occur throughout the sere, e.g. the ground beetle, *Galerita janus* Fab., and the small staphylinid, *Erchomus ventriculus* (Say), which may be taken in any or all of the communities, the former on the floor under objects by day, active by night and passing the cold months beneath bark; the staphylinid occurring beneath bark of practically all of the trees of the forest, generally in the earlier stages of log succession, especially between loose bark and moist sapwood.

There are a number of factors which tend to materially alter the normal fauna of an associes: (1) the inevitable straying of species from their normal ranges, whether involuntary or driven by winds, etc. This applies especially to the cottonwood associes where its proximity to the beach complex raises the total number of species. (2) The distribution of dung-inhabiting, and coprophagous species, e.g. *Sphaeridium scarabaeoides* (Linn.), *Onthophagus hecate* Panz., *Aphodius fimetarius* (Linn.), *A. distinctus* (Mull.), *Geotrupes splendidus* (Fab.), and of carrion inhabiting and saprophagous species, e.g. *Silpha inaequalis* Fab., *S. noveboracensis* Forst., species of *Necrophorus*, Histeridæ, and Staphylinidæ, throughout the entire sere. (3) The species which consort along moist margins of streams

and ponds, e.g. many species of *Platynus* and *Chlaenius*, many Bembidini, and those inhabiting meadow margins and secondary associes, as pastures, e.g. *Badister pulchellus* Lec., *Calleida punctata* Lec. and many Chrysomelidæ, etc. tend to swell the number of species of a forest community, notably along the tension zones or ecotones.

II. Seasonal Succession in the Chicago Area.

The present section will attempt to show seasonal succession of Coleoptera in the Chicago area throughout the year, in addition to certain special aspects of seasonal activity.

The average ecological year may be broken conveniently into at least two periods, that is, the late autumn-winter-early spring period, and secondly, the late spring-summer-early autumn period. In the former the foliage is scanty or absent in the deciduous communities, the mean temperature is low, and the daylight intensity is low but the floor illumination is relatively high due to the small amount of shade. In the second period, the amount of forest floor shade is greatly increased in the deciduous communities, the daylight intensity has increased, the mean temperature is higher, and there is a relative increase in the length of day over night, to mention only a few differences. With these changes there is an equally sharp change in the distribution and behavior of beetles inhabiting such an upland forest sere.

The same general condition is found if the four seasons are considered. However, in this case the spring (or period of foliation, of emergence from hibernation, and the beginning of migration) is in sharp contrast with the autumn (or period of defoliation, and of entering into hibernation). Thus the average ecological year presents four well defined seasons, with the vernal and autumnal periods of activity altering the aspect of the average cycle, e.g. the cycle in deciduous forests which have as their relatively static phases the presence and absence of leaves.

By breaking the seasons into months, we find that there is a regularity of beetle distribution throughout the year, but certain forms occur regularly certain months, or in certain definite fractions of a given period. The result is a regular succession of beetles as well as a rise and fall in the numbers of individuals of a species.

TABLE III.

SEASONAL DISTRIBUTION OF FAMILIES, BASED ON RECORDS OF ACTIVE SPECIES OF COLEOPTERA.

FAMILY	TOTAL SPECIES	JAN.	FEB.	MAR	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.
Cicindelidæ	11				3	7*	4*	5	5	4			
Carabidæ	122		1	14	37	65	56	40	36	39*	28	11	3
Hydrophilidæ	1				1	1				1	1		
Leptinidæ	1										1		
Silphidæ	12			3	4	1*	4	5	2				
Orthoperidæ	1					1		1					
Staphylinidæ	34			3	15	22*	10	7	3	4	7	2	
Clavigeridæ	1					1							
Scaphidiidæ	4					1	2			1	1		
Histeridæ	16			3	5	10	10	2	5	1			
Lycidæ	2						1			2			
Lampyridæ	4					1*	1	4	2		1	1	
Cantharidæ	13					2	8*	4	3				
Melyridæ	4					1	1	2	2				
Cleridæ	7					1	3	4	1				
Corynetidæ	3				1		1	1			1		
Oedemeridæ	2					1	2	1					
Mordellidæ	14						7	10	4				
Meloidæ	3							2	1	1*		1	
Pyrochroidæ	1							1					
Pedilidæ	5						3	2	1	1			
Anthicidæ	1					1		1					
Elateridæ	22			1	9	9	3	5		3	1	2	3
Eucnemidæ	2					1	1						
Buprestidæ	12					1	3*	8*	2	1			
Helodidæ	2					1	1	1	1			1	
Dermestidæ	4						3			1			
Byrrhidæ	1					1							
Ostomidæ	2				1	2							
Nitidulidæ	12			1	5	4	3	3	3	3	1		
Monotomidæ	2					1		1					
Cucujidæ	10			1	6	4		2		3	3	1	
Erotylidæ	9				2		3*	5	1				
Cryptophagidæ	8			1	5*	8*	2		2				
Mycetophagidæ	2				1	1	1	1					
Colydiidæ	3			2	2	1		1					
Mycetaeidæ	1				1							1	1
Endomychidæ	2			2	1								
Coccinellidæ	23		1		8	13	4	11	13*	5	8	4	1
Alleculidæ	5						2	4					
Tenebrionidæ	11			1	5	7	3	5	2	1	1	1	
Melandryidæ	7				2	2	3	3	1		1		1
Lyctidæ	1							1					
Cisidæ	1				1								
Scarabaeidæ	40			2	6	16	21	10	6*	12	2	1	
Trogidæ	4						1	1	3	1			
Lucanidæ	4				2	3	1	2	1	1			
Passalidæ	1				1			1			1		
Cerambycidæ	39				1		18*	19*	9	5			
Chrysomelidæ	90			8	15	40*	39*	37*	27*	12	11	4	5
Mylabridæ	1							1					
Brentidæ	1		1				1	1					
Curculionidæ	24			1	4	7	8	7	10	9	1	2	
Scolytidæ	2				1		1						

* Observed in copulation.

It is further found that an assemblage of species, e g a family, may in some cases follow a definite cycle of activity, that is, a period of low activity in which the species are hibernating, or have otherwise disappeared and few or none are active. This is followed by the gradual and regular appearance of species, one after another, together with a gradual increase in individuals. This increase in activity to a peak occurs with many species in the spring or summer, but in some in the autumn, e.g. many lampyroid and cantharoid species and certain of the Meloidæ. Finally the number of active species grows fewer or even disappears entirely, as the individuals migrate, die or go into hibernacula at the approach of cold weather Such a rhythmic distribution is indicated for the Coleoptera in the Chicago area in Table III.

In Table IV the number of active species appearing each month is given, and their percentage values with respect to the total number of species available with seasonal data

TABLE IV

SEASONAL DISTRIBUTION OF SPECIES OF ACTIVE BEETLES IN THE CHICAGO AREA, AND PERCENTAGE VALUES

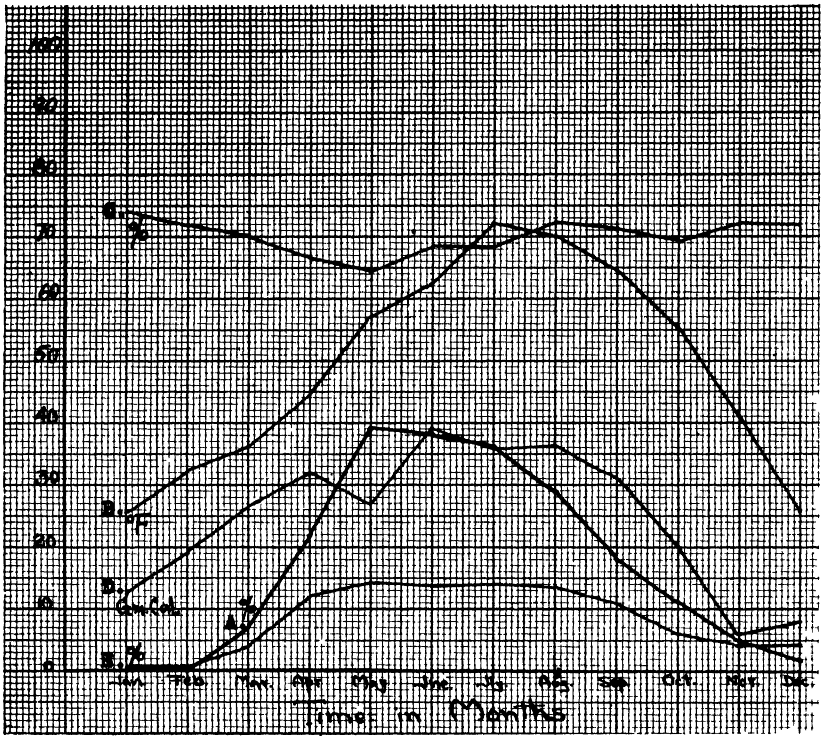
Total Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
610		3	43	145	238	235	222	146	111	70	32	15
100.00%		49	7	22	39	38.5	36.3	20.3	18.1	11.4	5.2	2.4

These figures give a regular curve (Graph I, A) which tends to show the maximum during May. Such a peak suggests a possible close correlation with the development of foliage, e g. food plants, rather than with such factors as temperature, daylight intensity or relative length of day over night, humidity and other factors reaching their maxima later in the year in this region. The maximum number of species appearing in May apparently represents an optimum of a number of factors, however, including a larger amount or variety of freshly developed foliage, and a favorable range of temperature and humidity. To this list daylight intensity may need to be added as a direct factor, as well as a factor influencing leaf development and modifying temperature and humidity changes.

These data certainly indicate regular seasonal distribution in beetle sere, as has been shown by Fritsch (1851, a, b) for

Coleoptera in the vicinity of Prague, and by other later investigators.

The Beach Drift as a Seasonal Calendar.—Seasonal regularity under normal conditions is well known for organisms in general, and in this report any community studied (save the pioneer



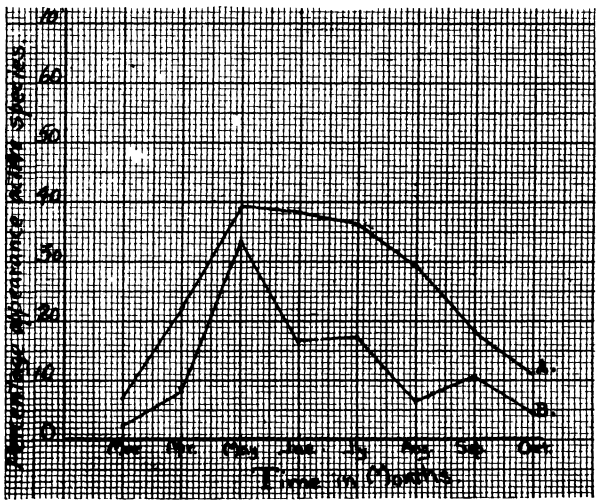
GRAPH I. Seasonal Distribution of Active Coleoptera in the Upland Forest Sere of the Chicago Area, based on data collected for 81 months, from April, 1922, to December, 1928, with the seasonal distribution of various factors for the same period where possible.

A. Seasonal distribution of active species.
B. Mean monthly temperature for Chicago (1926, 1927, 1928). Courtesy of the University Observatory and Chicago Weather Bureau.
C. Mean monthly relative humidity for Chicago (1926, 1927, 1928). Courtesy from above stations.
D. Radiant energy in gram-calories. Courtesy from above stations.
E. Percentage of Field Trips taken each Month.

conifer associes) could be used to show the advance in the monthly cycle. The beach complex is especially adapted to our purposes however, since it is highly concentrated within a

limited area, and we have found the beach drift to be a biological calendar in consequence of this periodicity.

Thus a part of the fauna is blown into the lake (Lake Michigan) and eventually aids in the formation of the lower beach drift, often a few days after its appearance in its regular habitat. In the drift it becomes the prey of other species living on the beach, and seeking the living or dead organisms as a part of their daily economy, e.g. some Carabidæ, Staphylinidæ, Silphidæ, Histeridæ, Nitidulidæ, Trogidæ, Scarabaeidæ,



Graph II. Seasonal Distribution of (A) Active Coleoptera in the Upland Forest Sere (all the data for 81 months), and (B) Active Carabidæ in the Lower Beach drift of Lake Michigan, based on two field trips per month from March to October

etc. The biocoenose of the drift has been investigated previously by a number of workers (Wheeler, 1887; Needham, 1900, 1904, 1917; Snow, 1902; Herms, 1906; and Shelford, 1913, pp. 218-221) and needs no further general treatment here.

In the following table the monthly appearance of the species of Carabidæ in the lower beach drift of Lake Michigan along the sandy depositing shores between Tremont and Miller's, Indiana is given. This family is chosen for its large size, and abundance of drift inhabitants, forming a majority of species known to occur in this community (Table II) over the 81 months of observation. Of the trips taken to the beach drift,

the two trips yielding the maximum number of species for each month, from March to October (inclusive) were selected, so that the number of trips each month would be constant. The average period of collecting and of observation of the biocoenose was between 12 noon and 2 P. M.

TABLE V.

SEASONAL DISTRIBUTION OF ACTIVE SPECIES OF CARABIDÆ IN THE LOWER BEACH DRIFT.

TOTAL SPECIES	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	OCT
125	3	10	42	21	22	8	13	6
100 00%	2 4	8	33 6	16 8	17 6	6 4	10 4	4 8

These data are comparable to the seasonal distribution data for all of the active species of Coleoptera of the upland forest sere (Graph I), and the two curves are plotted (Graph II) to show their similarities.

It will be seen that the curves in this second graph are very similar in the spring (March to May) and in the autumn (September to October) and in both the maximum number of active species, whether for all the families of the entire sere or the Carabidæ of the drift, is present in May. The summer season shows a regular drop in the appearance of active species for the entire forest sere and an irregular drop for the Carabidæ of the beach drift. Such irregularities may very well be a consequence of the vagaries of collecting. However, the uneven summer curve may be, due to wind action, preventing the proper accumulation of drift along the shore; or to a biological rhythm.

With regard to the peak in May, the maximum foliation is reached later in the year, as will be shown in a later paper, and consequently when the majority of species emerge in May, foliation is not at a peak and there is less food for the herbivores and less shelter. Such a condition may cause a period of aimless wandering. If this is true then many species would tend to appear in the drift, or again, the lack of shelter may expose them to winds, and eventually force many into the lake and finally into the beach drift.

Further data show the beach drift to be of value even as a species calendar to a certain extent. Data accumulated on

actual occurrence of species can not be given here due to lack of space. Suffice it to say that in general, the species inhabiting the forests of the dune sector are regularly represented in the drift, in many cases shortly after appearing in their regular habitat.

The Evidence from Data on Hibernation.—In many species there is a hibernation rhythm which tends to swell the population of forest floors offering protected hibernacula, such as the more mesophytic associes and climax associations This influx begins in the late autumn, and corresponding depopulation takes place in the following spring. Whether due to the inherent character of these forest associes, or to their increasing distance from wind and subsequent sand blast action associated with Lake Michigan, or a combination of both, the number of hibernating species of beetles increases with the increase of distance from the lake. However, from the seral point of view the specific composition of pioneer communities changes with the onset of hibernal conditions, and there is a tendency to level out the different community curves. This change in seral character is, in part at least, as expression of seasonal succession, and at this point seral and seasonal succession are inevitably combined. Holmquist (1926, p. 406) finds this to hold for hibernating arthropods in general, "The distribution of the species of the various forest associations seems to show a great deal of over-lapping, and a breaking down of boundaries between the various summer associations due to the fewer number of limiting factors and to their more cosmopolitan distribution in the various ecological associations."

Thus in the cottonwoods, the shallow leaf covered depressions, and the more protected floor around the bases of trees are scantily protected. These habitat niches, or the rare occurrence of dead trees in the early stages of decay, are used for hibernacula. In the conifers the floor is protected by some humus and a continual fall of needles which tend to mat so that they are not readily blown away. Again, the trees are more close together than in the cottonwoods and the distance generally from the lake is greater so that the cottonwoods and fore-dunes act as buffers. Decaying logs are more abundant, and these and the heavier humus increase the number of suitable hibernacula. In the black oak associes, and finally in the climax forest associations, these conditions are regularly

cumulative until in the latter the forest floor is well protected by a heavy, rich, moist layer of leaf mould and debris, and many species of Coleoptera move into these strata from other less suitable places or from different associes. Consequently there is, at the approach of cold weather, a vertical migration of species from the defoliated upper strata, and a horizontal movement into the floor from the more pioneer associes.

That such a situation exists may be illustrated by the following data on a very few of our well known forms. One such group showing a biannual intercommunity movement is found in some of the Coccinellidæ. To mention one species, *Ceratomegilla fusilabris* (Mulsant) has been observed at intervals for the past four years and a summary of its distribution may be indicated as follows:

Usually from the end of May to the middle of October the species is present in great numbers scattered over the herbaceous and shrub strata of the subclimax associes, especially along forest margins, and in meadow and secondary communities, e.g. pastures and gardens. It may be taken throughout the entire upland forest sere, as solitary individuals or in small groups gathered due to proximity of food, viz. hunting and devouring of aphids, etc. During this time it may occur in the beach drift, often present by thousands.

As winter approaches the species becomes more scarce and solitary individuals actively hunting on foliage gradually begin to disappear. At the same time the species is found more abundantly in protected places. These latter, as would be expected, may be such secondary locations as the bases of orchard trees, garden walls, loose boards, etc., but in the upland forest sere the movement is into the more mesophytic forests on their floors or in the leaf mould, and along the margins of such communities. When winter sets in this lady beetle is found aggregated under leaves and debris of the subclimax and climax floors, often in gatherings of several hundred or more.

The winter is passed by the majority of individuals of this species in this way. In late spring the aggregations are found nearer the surface of the floor and are more active. In the Chicago area April appears to be the critical month for emergence. As early as April 6, gatherings on the floor of the climax maple association at Joliet, Illinois, just under the top leaves,

are common; 50% of the group may be moderately active on the surface leaves and debris, and 50% still buried in the leaf mould and relatively inactive. The animals become more and more restless, until by the end of April they are crawling actively over the floor and greening herbage, single or in groups of as high as thirty or forty individuals. By the middle of May, this species has spread and scattered over the upland forest sere, and adjacent secondary communities. It is now represented by individuals, rather than aggregations, save for the forced gatherings in the lower beach drift. The drift records its presence in numbers by May 19, as a rule and the species is taken in this community through the summer and autumn, often represented by enfeebled individuals after the majority have moved into their winter hibernacula.

The data so far are typical for *C. fusilabris*. Blatchley (1910, pp. 510-511) finds the species common throughout Indiana, and gives its seasonal range as "January 12-- November." He finds it "Gregarious in winter. During October it congregates beneath mullein leaves, etc. On several occasions I have found them in midwinter by the thousands, huddled together beneath piles of the stems of the larger ragweed (*Ambrosia trifida* L.) in the low bottom lands of the Wabash river." Cook (1898, p. 117) finds *Megilla vittigera* and *Hippodamia ambigua* clustered, and thinks that "they cluster to protect each other from the cold," a view different from that held by many. Calvert (1899, p. 68) fide Conway, mentions coccinellidæ grouped on or in the ice, and *Megilla* (*Ceratomegilla*) and other coccinellids are well known for their gregariousness in cold weather; even in spring and summer (Hamilton, 1885; Schwarz, 1891, p. 169; Hawkes, 1920, pp. 484-5; Carnes, 1912; Van Dyke, 1919).

Without painful repetition of detail, similar data is at hand on coccinellids of similar habits, e.g. *Hippodamia tredecimpunctata* (L.), *H. parenthesis* (Say), *H. convergens* Guer., and *Coccinella novemnotata* Hbst., in addition to many species from other families, e.g. the chrysomelid herbivore *Lema trilineata* (Oliv.) which is found in winter either singly or in small groups with *Ceratomegilla fusilabris*, these two species often being associated during the hibernal season. Blatchley (loc. cit., p. 1111) finds *L. trilineata* frequent, throughout the state, from April 19 to July 25. "Occurs on the foliage of various Solanaceous

herbs, especially that of potato . . . . Mating June 8." So that this species may be regarded as one not characteristic of the more mesophytic forests, but taking advantage of the protected floor on occasion in winter.

Over-wintering Aggregations in Coccinellidæ.—The tendency of many of our common species of coccinellids to collect, especially in winter, is well known and the phenomenon has been frequently observed as indicated by the few references already cited. However, observation of these gatherings, from the viewpoint of one interested in crowding physiology, is less common and since these over-wintering aggregations are further important as a consequence of seasonal activity, one such gathering will be taken up in some detail.

On October 20, 1928, *C. fusilabris* was observed around the base of a *Crataegus* bush, some five feet high. The surface leaves were but sparingly inhabited by the beetles, usually in small groups of from four to five, or singly. Beneath this superficial layer, and throughout the rich, moist earth of the sub-climax oak-elm-hickory forest (New Lennox, Illinois) the species was present in great numbers. A square yard of this mould was selected for a rough census. On sweeping up one layer of this yard no beetles would at first be seen. In several seconds the beetles would appear, apparently making their way up from still deeper layers, until the square yard had been excavated evenly for six inches, that is, the census was made on the inhabitants of 7,776 cubic inches of floor.

At this time of day (2:30 P. M.) the air was 20.5° C., in the sun, the floor surface 13.5° C., under this superficial leafy layer 14° C., and four inches into the mould 13° C., so that between 13° and 14° C., the aggregation was still moderately active.

That this same area had been used previously, was indicated by bleached and fragmentary portions of *C. fusilabris*, buried and scattered in the humus.

The aggregation was composed of 9,808 individuals in the square yard excavated, or over one to a cubic inch, and many hundreds must have escaped during the period of excavation so that the total is a conservative one. This species forms a loose aggregation, and is "homodynamic" as to its character of hibernation after the terminology of Robaud, or exhibits "false hibernation" of Holmquist (1928 a, p. 349). The

species is not essentially gregarious in the warmer months. On the breaking up of winter, and the appearance of aphids on the vernal foliage, it leaves its hibernacula and spreads out fan-wise over the surrounding region, so that its being found in numbers in the summer is probably due to a concentration of its prey. In winter its gregariousness is probably due to a complex of conditions, too involved to be readily explained by any one factor. The concentration in winter is thought to be a consequence of numerous individuals collecting at certain suitable niches, and hence crowding by late arrivals forms the over-wintering aggregation. This is essentially a "shelter aggregation" (Allee, 1927, p. 374), however other conditions may, and probably do, influence the extent and nature of the bunching. Thus Allee notes that (loc. cit., .374) "not all the apparently equally desirable space is occupied, so that the aggregation can not be entirely explained on the basis of unavoidable crowding. In other cases Holmquist has been unable to find any environmental differences to account for the location of the hibernating aggregation. These groupings are partially under temperature control, but as with other phenomena connected with hibernation, the temperature control is incomplete and the problem of the exact nature of the casual factors remains open." Holmquist (1926, p. 406) finds that "distribution of arthropods in winter seems to be determined chiefly by kind and amount of shelter and by moisture."

Shelter and moisture are probably important in the very loose over-wintering aggregation of the western *Cicindela oregona* Lec. (*C. senilis* Csy.) as described by Blaisdell (1912) where these predators abandon their solitary life at the approach of cold weather and burrow under flat rocks. Crowding forms a forced gathering under the latter, in a type of central chamber.

Moisture is certainly an important factor in the more closely integrated over-wintering aggregation of certain species of *Saprinus*, especially *S. rugifrons* Payk., *S. rubripes* Erichs., and *S. rugiceps* Duft, as recorded by Spett (1925) at Kiew. These histerids occupy bare sandy patches devoid of vegetation in colonies numbering from 100 to 1000 for several square meters. The colonies are extensive and are limited largely to the upper 16 centimeters of sand. They remain in the sand for some eight months of the year, and their movements in the sand are largely vertical migrations in search of dry, warm

strata, hence weather conditions and time of year alter their activity.

Similarly shelter, as a means of protection from the cold, and probably moisture play important roles in the over-wintering colonies of *C. fusilabris*. That all available space on the forest floor is not occupied is indicated by the fact that a control site of the same size and on an equally rich part of the forest floor fifty feet from the *Crataegus*-bush colony yielded no *fusilabris*. The first control, however, was not near any *Crataegus*. Other *Crataegus* bushes in the same community were examined, and the soil at their bases held no *fusilabris* colonies, and only a few scattered individuals of this species (several to a square foot), a condition often met with as the normal distribution in many areas.

This aggregation of *fusilabris* of October 20 was mixed or heterotypic, as also may be the case with the *Saprinus* colonies as noted by Spett (loc. cit.), and contained, in addition to *Ceratomegilla*, the following animals, however in great minority:

Annelida (Oligochaeta), 5 Lumbricidæ; Arthropoda (Araneida),* Attidæ—1 ♂, 4 ♀ half-grown *Phidippus audax*, 1 ♂, 1 ♀ *Maevia vittata*, Drassidæ—1 ♀ *Zelotes ater*, Clubionidæ -2 ♂, 3 ♀ *Clubiona canadensis?* *Anyphaena gracilis*, 1 half-grown ♀; (Isopoda), 5 Oniscoidea; (Coleoptera) Coccinellidæ many *Scymnus*, 12 *Psyllobora viginti-maculata* (Say) 2 *Hippodamia tredecimpunctata* (L.), 1 *Cycloneda sanguinea* (L), Corylophidæ—many, Lathridiidæ 2, Cucujidæ—2 *Telephanus velox* Hald., Cryptophagidæ—2 *Tomarus pulchellus* Lec., Chrysomelidæ—1 *Lema trilineata* (Oliv.); (Hemiptera)† Pentatomidæ—*Peribalus limbolarius* Stal., Coreidæ—1 *Catorhintha mendica* Stal., 1 *Corizus lateralis* Say, Lygaeidæ—*Myodochus serripes* Oliver, Miridæ—*Lygus pratensis* Linn.?

Light as a Possible Factor.—That the causes underlying the crowding physiology of such hibernating species (probably a form of "shelter aggregation" of Allee, 1927 b, p. 374) are complex, and interdependent, is suggested by the following observations in which light may prove to be one of the casual factors.

Some aggregations of hibernating beetles have marked responses to change in light intensity. Thus, a number of over-wintering *Ceratomegilla fusilabris* were brought into the laboratory and placed in a constant temperature cabinet and

*Determined by Dr. Sewall Wright, University of Chicago.

†Determined by Mr. William J. Gerhard, Field Museum of Natural History.

the temperature lowered to 10° C. This drop in temperature was accompanied by a gradual cessation of activity. From October 22 (8:30 A. M.) to October 25 (9:35 P. M.) the temperature was held at 6.5° C., and the beetles were inactive at this temperature, e.g. were in a dormant state approaching that of the sluggish, hibernating individuals.

At a temperature of 23.5 C. (approximately 74 F.), the laboratory animals were positive for daylight and for light from a 60 Watt Mazda lamp acting at two feet. At this temperature they were active, crawling rapidly or flying frequently, and if liberated would fly towards the light or the windows. In short, their behavior was that found in late spring and early summer months.

At approximately 10° C. the species tended to become photo-negative and the individuals gave a digging response which may indicate that under similar conditions of the normal habitat, they would tend to fly to the dim, mesophytic floors and burrow into the mould. The relative values of shelter, temperature, light, moisture and gravity obviously belong to experimentation of the most exacting nature. Weiss (1913), working on the tropic response of *Ceratomegilla fusilabris* (*Megilla maculata*) thinks that colonial hibernation in this species, in winter, is a consequence of a complex of "tropic stimuli," and congregation in large numbers may be due to chemotropism (p. 85). "A lowering of the temperature as winter approaches with a corresponding decrease in food supply undoubtedly renders them exceedingly susceptible to chemotropic stimuli. With *Megilla maculata*, there is no evidence at present that anemotropism plays any part in the selection of the hibernation quarter. Once in the place of hibernation, they become positively thigmotropic and negatively phototropic."

The experimental results of Weiss (loc. cit.) on *fusilabris* are closely comparable to my own on hibernating individuals of the same species, and especially point out the possible role of light in the elicitation of the hibernation response. Many observers, e.g. (Holmquist, 1926, 1928 a, b) have found temperature an undoubted factor, which is further indicated for *fusilabris* by the work of Weiss and the results presented here. Weiss thinks chemotropism and decrease in temperature the factors causing this coccinellid to seek its hibernaculum. How-

ever, it is probable that once the site is reached, other factors such as relative humidity and relative degree of moisture as well as a lowering of the threshhold for contact, becoming positive for gravity or negative for intensity of daylight within a certain range, must determine the conduct of the animals. Thus light may be of primary importance in causing a species to bury itself in the mould of a forest floor, an impelling factor playing an important part after temperature and other factors had served to bring the animal to a given habitat.

Similarly, as the soil grows warmer and moister in the spring season, the animals become active accordingly as their rate of metabolism rises. Such an increase in activity is noted here for *fusilabris*, and is a well known phenomenon. Spett (loc. cit.) notes the marked increase of activity in the over-wintering colonies of *Saprinus* at the approach of warm weather. But this increase in activity is not sufficient to cause *fusilabris* to emerge from their floor or under-bark hibernacula, unless the beetles tend to follow a moisture or a temperature gradient of the soil. Once on the surface, the intensity of daylight, falling through the scantily shaded forest canopy, may play an important part in causing the aggregation to break up and crawl or fly to warmer or more illuminated areas, e.g. the forest margins or open secondary communities. Again we note that given the skein of observational data, the ultimate solution rests with experimentation.

It is interesting to observe that hibernation is the ecological equivalent of migration in many species, and the recent work of Rowan on relative length of day and night as an important factor in the migration of some birds (Rowan, 1925, 1926, 1927; Allard, 1928) may play a part in the hibernation of other species of animals. Allard (loc. cit.) in connection with Rowan's photoperiodism, mentions (p. 406) that the "common May beetles (*Phyllophaga* spp.) not alone fly into our lights, but they may under certain conditions show the same tropistic light response toward brilliant twilights of the summertime." Duplication of Rowan's work on a smaller scale with such forms as the Monarch butterfly (*Danaus archippus*) which are known to have a migratory rhythm should yield data on the general problem.

SUMMARY.

In summary, it may be said, despite many influences at work, it is readily seen that a beetle sere exists which corresponds to the upland forest sere in the Chicago area, whether the species are arranged according to total distribution of species or individuals, or by characteristic and peculiar forms. It is probable that a combination of all three points of view are necessary to obtain even a moderately accurate picture of the beetle distribution in a given community.

There is a definite seasonal succession throughout the year in addition to seral succession.

This seasonal periodicity however is dependent upon various conditions for its expression, and is shown in condensed and abbreviated form by the beach drift of Lake Michigan, viz. the drift can be used as a rough biological calendar given sufficient data on its population.

Again, hibernation is seen as a rhythmic seasonal occurrence in certain species, and the over-wintering of certain forms is discussed.

Although it is recognized that hibernation is a complex phenomenon in which many factors are operating, it is suggested that daylight intensity or possibly the relative length of day and night may play a part in this obscure and recurrent condition.

BIBLIOGRAPHY.

Allard, H. A. 1928. Bird Migration from the Point of View of Light and Length of Day Changes. Am. Nat., 62: 385–409.

Allee, W. C. 1927. Animal Aggregations. Quar. Rev. Biol., 2: 367–398.

Blaisdell, F. S. 1912. Hibernation in Cicindela senilis. Ent. News, 23: 156–159.

Blatchley, W. S. 1910. Coleoptera or Beetles (exclusive of the Rhynchophora) known to occur in Indiana. Nature Pub. Co., Indianapolis, 1,386 pp.

Calvert, P. P. 1899. Massing of Coccinellidae (a note). Ent. News, 10: 68.

Carnes, E. K. 1912. Collecting Ladybirds by the Ton. Monthly Bull. State Comm. Horticulture, Sacramento, California, 1: 71 81.

Chapman, R. N., Mickel, C. E., Parker, J. R., Miller, G. E., and **Kelly, E. G.** 1926 Study in the Ecology of Sand Dune Insects. Ecology, 7: 416–427.

Cook, A. J. 1898. Massing in Coccinellidae (a note). Ent. News, 9: 117.

Cowles, H. C. 1899. The Ecological Relations of the Vegetation on the Sand Dunes of Lake Michigan. Bot. Gaz., 25: 95–117; 167 202; 281-308; 361–391.

———. 1901. The Plant Societies of Chicago and Vicinity. Geog. Soc. Chicago, Bull. No. 2.

Fritsch, K. 1851a. Ueber die jahrliche Vertheilung der Kafer. Sb. der. math.-naturwiss. Classe, K. Akad. Wissen., 6: 3–42.

———. 1851b. Resultate zweijahriger Beobachtungen uber die jahrliche Vertheilung der Kafer. ibid, 7:689–710.

Fryxell, F. M. 1927. The Physiography of the Region of Chicago. Univ. of Chicago Press, 55 pp.
Graham, V. O. 1927. Ecology of Fungi in the Chicago Region. Bot. Gaz., 83: 267–287.
Hamilton, J. 1885. Hibernation of Coleoptera. Can. Ent., 17: 35–38.
Hawkes, O. A. M. 1920. Observations on the Life History, Biology, and Genetics of the Ladybird Beetle Adailia bipunctata (Mulsant). Proc. Zool. Soc. London, pp. 475–490.
Herms, W. B. 1906. An Ecological and Experimental Study of the Sarcophagidae with Relation to Lake-beach Debris. Jour. Exp. Zool., 4: 45–83.
Holmquist, A. M. 1926. Studies in Arthropod Hibernation. Ann. Ent. Soc. Am., 19: 395 426.
————. 1928a. Studies in Arthropod Hibernation. II. The Hibernation of the Ant, Formica ulkei Emery. Physiol. Zool., 1: 325-357.
—. 1928b. Notes on the Life History and Habits of the Mound-building Ant, Formica ulkei Emery. Ecology, 9: 70 87.
Leng, C. W. 1920. Catalogue of the Coleoptera of America, North of Mexico. J. D. Sherman, Jr., Mount Vernon, N. Y.
————. 1927. Supplement to Catalogue, (1919–1924), ibid.
Needham, J. G. 1900. Insect Drift on the Shore of Lake Michigan. Occ. Mem. Chicago Ent. Soc., 1: 1–8.
————. 1904. Beetle Drift on Lake Michigan. Can. Ent., 36: 294 95.
————. 1917. The Insect Drift of Lake Shores. ibid, 49: 129–137.
Rowan, W. 1925. Relation of Light to Bird Migration and Developmental Changes. Nature, 115: 494–495.
————. 1926. On Photoperiodism, Reproductive Periodicity, and Annual Migration of Birds and Certain Fishes. Proc. Boston Soc. Nat. Hist., 38: 147–189.
1927. Migration and Reproductive Rhythm in Birds. Nature, 119: 351–352.
Salisbury, R. D. and **Alden, W. C.** 1899. The Geography of Chicago and its Environs. Geog. Soc., Chicago, Bull. No. 1.
Schwarz, E. A. 1891. Massing of Coccinellidae (a note). Ent. News, 2: 169.
Shelford, V. E. 1913. Animal Communities in Temperate America as Illustrated in the Chicago Region. Geog. Soc. Chicago, Bull. No. 5.
Snow, L. M. 1902. The Microcosm of the Drift-line. Am. Nat., 36: 855 864
Spett, G. 1925. Beobachtungen uber Geselligkeit (Koloniebildung) bei uberwinternden Kafern der Gattung Saprinus. Zeit. fur wissen. Insektenbiologie, 20: 5–8, Heft 1.
Van Dyke, E. C. 1919. Tendency of Insects to Collect on Ridges and Mountain Snowfields. Ent. News, 30: 241–244.
Weiss, H. B. 1913. Some Tropic Reactions of Megilla maculata DeG. and Notes on the Hydrotropism of Certain Mosquitoes. Can. Ent., 45: 85–87.
Wheeler, W. M. 1887. On the Distribution of Coleoptera Along the Lake Michigan Beach of Milwaukee County. Proc. Nat. Hist. Soc. Wisconsin, April, pp. 132-140.

THE MORPHOLOGY OF THE REPUGNATORY GLANDS OF ANASA TRISTIS DE GEER.*

DELBERT L. MOODY,
Department of Entomology, Iowa State College.

INTRODUCTION.

The property of some Hemiptera, more especially the Pentatomidæ and Cimicidæ, of emitting an offensive odor when disturbed or injured has been known for many years. The first record of the source of the secretion which produces this odor showed it to be a gland in the ventral part of the metathorax opening to the exterior by ducts on either side in front of the hind coxæ. Later it was found that similar glands in some of the dorsal segments of the abdomen of the nymphs had the same property but upon molting to the adult stage these glands disappeared and were apparently replaced by those in the metathorax without any change in function.

Because of this interesting change in position of the repugnatorial glands in the immature and adult stages of some Hemiptera, the writer has undertaken to work out in some detail the morphology of these glands in the nymphal and adult stages and to determine the relation of the abdominal glands in the nymph to the metathoracic gland in the adult.

The squash bug, *Anasa tristis* De Geer was chosen for this work because of its abundance, rapid reproduction over a long period and its convenient size. The morphology of the repugnatorial glands in this insect had not been investigated although the life-history and external anatomy have been thoroughly studied.

REVIEW OF LITERATURE

In reviewing the literature no paper was found dealing specifically with the repugnatorial glands of *Anasa tristis* De Geer and where scattered references were made in any paper

*The writer is greatly indebted to Dr. W. H. Wellhouse, under whose direction this research was taken, for suggestions and encouragement in carrying on the investigation, and to Dr. H. H. Knight, with whom the work was continued in Dr. Wellhouse's absence.

the subject was dismissed with a few sentences. Some work of a general nature, however, has been done on repugnatorial glands in other species of Hemiptera.

Leon Dufour (1833) published the first account of repugnatorial or stink glands in the adult stages of Hemipterous insects, but Kunckel (1866) was the first to observe the presence of stink glands in the dorsal surface of the abdomen of the nymphs of certain Hemiptera and that these dorsal glands in the nymphs atrophied during the last instar and were replaced by metathoracic glands in the adult. Kershaw (1907) in studying the life-history of *Tessaratoma papillosa* Thunberg discovered that the dorsal glands in the nymph remained in the cast skin as two soft yellow sacs enveloping a yellowish fluid which had the same characteristic odor of the metathoracic glands in the adult.

Discussion.

Glandular Apparatus in the Adult.

Source of Secretion.

When one picks up a squash bug he is usually struck with a rather sharp odor suggestive of amyl acetate. The source of this odor is an oily liquid which is discharged through an opening on each side of the metathorax between the coxæ of the middle and hind legs (Plate II, Fig. 4). The opening, termed an ostiole, is situated at the outer end of a chitinized duct or vestibule (Plate V, Fig. 2), which is connected at its inner end with a sac that acts as reservoir for the liquid secreted by a pair of glands which empty into it. These glands consist of a mass of glandular tissue partly surrounding the reservoir and in intimate contact with it (Plate I, Fig. 2).

Position of Reservoir and Metathoracic Glands.

The reservoir is situated mainly in the ventral part of the metathorax below the digestive tract, but the posterior part extends into the first two segments of the abdomen (Plate I, Fig. 2). The glands in the adult are located in the anterior part of the metathorax the greater part of them lying above the anterior portion of the reservoir and its ducts (Plate V, Fig. 2); each gland extends caudad around the sides of the

reservoir for about a third of its length. The cephalic parts of the glands meet in the median line of the body over the anterior part of the reservoir and reach anteriorly as far as the posterior edge of the mesothorax where they lodge against the large tergo-sternal muscles. They are separated laterally from the body wall by the coxal muscles and a layer of adipose tissue.

The reservoir lies directly beneath the alimentary tract, being completely hidden by it when the internal organs are viewed from above. In the female the ovaries are located above and laterad of the sac, the terminal filaments extending forward beyond it into the mesothorax. In the male the testes are situated in a latero-posterior direction to the sac between it and the body wall and do not extend as far forward as the ovaries. In the breeding season the testes are enlarged and extend along the sides of the sac for one-third of its length. The gastric caeca, which are quite large in *A. tristis*, lie above the sac on either side of the mid-intestine in the male but the ovaries are between them and the sac in the female. The anterior part of the reservoir including the ducts is covered by the metathoracic gland. The glands extend around both sides of the sac and the anterior parts of them curve down over the cephalic part of the reservoir. The ventral nerve cord passes around the sac on one side or the other above the duct but under the main part of the reservoir (Plate I, Fig 2). Beneath the reservoir the body wall extends up into the body cavity in the form of a high transverse ridge formed by the junction of the metathorax and the first segment of the abdomen. Upon the ridge the sac rests while the space posterior to the ridge between the sac and the ventral abdominal wall is filled with a layer of adipose tissue. In addition to the ventral nerve cord there are three pairs of nerves arising at the ventral thoracic ganglion and passing around each side of the sac between the gland and the main part of the reservoir.

Location and Description of External Orifice and Vestibule

The external orifice in the adult is located in the metathorax between the epimeron and the episternum on a line with the third coxal cleft (Tower, 1913). It is slightly caudad and ventrad to the posterior thoracic spiracle (Plate IV, Fig. 5).

The orifice or ostiole consists of an ovoid slit surrounded by an extension of the body wall which forms a corneous ring around the opening. On the anterior side this ring is expanded into a flattened disk which narrows abruptly on the caudal side to form a ridge which extends toward the third coxa and forms a continuation of the coxal cleft. Starting from the dorsal side of the disk is another ridge extending around the other side of the orifice to join the first ridge and forms the other side of the coxal cleft. The disk and the ridges, termed the ostiolar peritreme, are yellowish in color being much lighter than the surrounding body wall. The surface of the ostiolar peritreme and the body wall for a distance of about .3 of a millimeter from the ostiole are very finely granular. This same area around the peritreme is also rugose. Setæ, much smaller and more erect than those on the body wall, are sparsely scattered over the peritreme and the granular area around it. The inside of the ostiole expands out somewhat to form the vestibule (Plate V, Fig. 2), a chitinous duct which leads into the reservoir.

The ostiolar peritreme at its greatest length measures .83 millimeters and at its greatest width .70 millimeters. The ostiole is .43 millimeters long and .21 wide. There is some slight variation in different individuals but the above figures give the average dimensions.

The vestibule is a barrel shaped chitinized duct leading from the ostiole on the outside to the duct of the reservoir (Plate III, Fig. 2). Its average size is .77 millimeters long and .34 millimeters wide. In cross section the vestibule is oval in outline, the long axis being parallel with the long axis of the body. The internal surface is resolved into deep grooves which run lengthwise of the vestibule. Directly in front of the opening of the duct in the reservoir and following along the anterior side there is a smooth area extending to the ostiole. This smooth area is curved posteriorly so that it approaches the ostiole at an obtuse angle and as a result of this curve the spray is discharged in a latero-posterior direction from the body. The internal surface has the same granular appearance as the ostiolar peritreme and the area surrounding it in the adult. The vestibule is constricted at both ends thus giving it the barrel shape.

Description of Reservoir and Metathoracic Glands.

The reservoir is a sack-like organ, orange in color and roughly heart-shaped in outline, with the pointed part extending posteriorly. On the ventral side of the anterior end of the main part of the sac there is a slight constriction (Plate I, Fig. 2) beyond which the reservoir widens out laterally to form two ducts which lead up to and connect with the chitinous vestibule. Incorporated in the surface of the sac are many small transverse ridges which present a wrinkled appearance to the surface. This wrinkled appearance is much more pronounced when the amount of fluid in the reservoir has become depleted.

When the reservoir is full of liquid its average length is about 3 millimeters and its width 2 5 millimeters in the mature adult. There is a great reduction in size of the sac after an ejection of the fluid, although in no case was the sac found to be totally collapsed.

The metathoracic glands consist essentially of two masses of tortuous convoluted tubes among which tracheal branches ramify abundantly (Plate II, Fig. 1). The tubes, which are circular in cross section, have approximately the same dimensions ranging between .45 and .55 millimeter in diameter. The tissue is white in color and granular in appearance when highly magnified It differs from adipose tissue in form and color. The adipose tissue is greenish and composed of lobes while the glandular tissue is tubular and white. The tubes composing the gland are very close together and are grouped around a small duct (Plate III, Fig. 2-d g) which empties into the reservoir near the mouth of its duct. The duct of the gland is very thin and membraneous in nature resembling somewhat the chitinous intima of the reservoir.

Tracheation of Reservoir and Metathoracic Gland

The main oxygen supply to the reservoir is received from two large tracheal branches, one bringing air to the sac from each side (Plate I, Fig. 2). These tracheæ arise from the first abdominal spiracle on each side and pass down the sides of the body wall to the sides of the reservoir where they attach a little posterior of the center of its lateral side. At this point each trachea divides into three smaller branches one of which

supplies the anterior part of the sac and its duct; another continues in the same direction as the main branch and supplies the median ventral part; the third passes caudad and supplies the hinder portion. There is no tracheal supply whatever to the dorsal surface of the reservoir. As far as could be determined the tracheæ connected only with the wall of the sac and did not pass through to the chitinous intima beneath. Since there is no muscular attachment to the reservoir, the large tracheal connections at the sides may serve as a partial support to it.

The metathoracic glands are more abundantly supplied with tracheæ than is the reservoir. The main branch furnishing a metathoracic gland with oxygen comes from the posterior thoracic spiracle (Plate I, Fig. 2). This branch enters the gland from a cephalo-lateral direction and divides into two parts one of which passes anterior to the gland across the thorax to meet a similar branch from the other side of the body; the other divides again, one branch going to the hind coxa and the other to the lateral side of the gland. From the branch which crosses the thorax three branches come off that go into the anterior part of the gland. These three branches supply the greater part of the gland with oxygen. It will be seen that since there are four large tracheæ which supply the gland an abundant amount of oxygen is assured.

Attachment of Muscles.

The number of muscles connected with the glandular apparatus in the adult is much less than that of the nymph. In the adult squash bug there are only two pairs of muscles, one of which is much larger than the other, connected with the glandular apparatus. These muscles serve to operate the valvular mechanism. The larger of the two muscles (Plate V, Fig. 2-g.m.) attaches at one end to the dorsal body wall in the metathorax between the scutellum and the pleura. It extends in a ventral direction to the valve where it attaches at its lower end to the flattened horizontal part (Plate III, Fig. 2-m.a.m.) of a chitinous arm (Plate III, Fig. 2-1.) that operates in part the valvular mechanism. The other muscle which is very small attaches at one end to the small chitinous arm (Plate III, Fig. 2-2) fastened to the median part of the folded sheet of the valve and the other end to the wall of the hind coxal cavity.

This muscle assists in pulling back the valve membrane to allow the liquid to flow out. No muscles were found attaching to either the gland or the reservoir.

Nerve Supply.

The nerves supplying the glandular apparatus of the adult were difficult to trace out. A small nerve arises from the ventral thoracic ganglion in the mesothorax just caudad of the origin of the large nerve entering the hind coxa. This small nerve passes in a latero-caudal direction to the large valvular muscle which it innervates (Plate I, Fig. 2). No nerves were found connecting directly with the gland and reservoir.

Mechanics of Operation of the Valvular Apparatus.

The valvular apparatus in the adult consists mainly of a folded sheet, three chitinous arms and two muscles (Plate III, Fig 2). The folded sheet, which is very tough and thick and has a granular surface, is located in the opening at the internal end of the vestibule at its junction with the duct of the reservoir. At its anterior edge the folded sheet is attached to a v-shaped chitinous arm (Plate III, Fig. 2-3) which is in turn joined to the vertical part of a larger chitinous arm (Plate III, Fig. 2-1). The larger chitinous arm, which is bent at right angles, has its horizontal part flattened out on its posterior side for the attach ment of the large valvular muscle (Plate I, Fig. 2). These two arms serve in part to open the aperture (Plate III, Fig. 2-ap.) through which the secretion passes to the vestibule. Another smaller chitinous arm (Plate III, Fig. 2-2) attaches to the middle of the folded sheet and serves also to pull back the sheet and open the aperture. When the two valvular muscles contract the chitinous arms to which they are joined are pulled in a dorso-posterior direction thus folding the sheet and enlarging the aperture.

Since there are no muscles connected with the reservoir to produce the force necessary to cause the liquid to be expelled for several inches, this force must be produced by other muscles of the thorax.

Range and Manner of Ejection.

When an adult squash bug is picked up in the field almost immediately some of the liquid is forced out part of which remains on the granular area surrounding the peritreme where

rapid evaporation takes place. Several bugs which had been kept in a cage for a few hours after ejecting a quantity of fluid were very slow to eject more liquid. Only by severely prodding the insect or injuring it as by pulling off a leg was the writer able to induce the bugs to emit any spray.

In order to determine the range of ejection an adult bug was placed on a large sheet of paper and strongly irritated. Several drops of liquid were forcefully discharged in a latero-posterior direction from the body to a distance of three to five inches. Five inches was found to be the maximum distance that the liquid could be thrown.

GLANDULAR APPARATUS IN THE NYMPH.

Source of Secretion in the Nymphs.

A somewhat different condition prevails in the immature insects from that in the adult. The glandular apparatus is located in the dorsal part of the abdomen and consists of two separate sacs which open to the dorsal surface between the fourth and fifth and the fifth and sixth segments (Plate I, Fig. 1). Each gland connects with the exterior by two ostioles, one on each side of a protuberance (Plate II, Fig. 3, 5) which forms a sort of vestibule beneath it. Each gland consists of a sac which may be flattened or distended to a globular shape according to the amount of liquid present within it. In gross structure the sac consists of an inner membraneous layer and a thicker outer one, the latter composed of glandular tissue in the form of alveoli (Plate IV, Fig. 1, 2). This outer layer is the only source of secretion in the nymphs.

Position of Abdominal Glands.

The abdominal glands in the nymphs are situated in the dorsal part of the abdomen in the fourth, fifth and sixth segments. The anterior gland lies partly in the fourth and partly in the fifth segment; the posterior gland lies partly in the fifth and partly in the sixth segment. The glands are very close together even overlapping each other slightly in some individuals (Plate III, Fig. 3). The digestive tract presses against the ventral side of the glands flattening them somewhat when it is distended with food. A thin layer of adipose tissue separates the glands from the dorsal body wall and extends

down over the sides and ends almost surrounding the glands. The heart is located directly beneath the glands in the median line of the body. Between the digestive tract and the glands are the Malpighian tubules which extend across the abdomen and project out on each side of the glands. There are masses of adipose tissue scattered among the tissue below the glands.

Location and Description of the External Orifice.

In the immature stages there are two pairs of ostioles each of which is located on either side of an oval swelling or protuberance on the dorsal surface of the abdomen These two protuberances, which will be called ostiolar prominences, are situated between the fourth and fifth and the fifth and sixth segments (Plate I, Fig. 1).

The ostioles are oval slits which in the fifth instar are .13 millimeters long (Plate II, Fig. 5). The anterior end of the ostiole is prolonged into the side of the prominence in a cephalo-lateral direction in the form of a deep narrow curved groove. Connecting the two ostioles at their posterior ends is a line marking the scar through which the gland lining is pulled out when a molt takes place.

Slightly laterad of the groove and immediately at the entrance of the ostiole is a trough-like depression with a fine granular surface similar to that of the peritreme in the adult This groove and depression serve, no doubt, to hold some of the liquid in order that rapid evaporation may take place The anterior, lateral, and middle part of the peritreme are of a solid brown color while the brown color in the surrounding surface is confined to spots around the setæ Scattered irregularly over the surface of the peritreme are short setæ Except for a slight difference in size, the two peritremes are almost exactly alike.

Description of Abdominal Glands.

The abdominal glands in a mature nymph consist of two thick walled orange colored sacs about a third as long as broad, which act both as glands and reservoirs (Plate III, Fig. 3). They are flattened somewhat dorso-ventrally by upward pressure of the alimentary tract beneath. The two glands are approximately of the same size and during the fifth instar they attain a length of 1.3 millimeters and a width of about 2 millimeters.

The walls of these sacs are made up of three layers: (1) an inner membraneous layer, the chitinous intima; (2) a middle cellular layer made up in the greater part of alveoli, which is the secreting tissue; (3) outside of this a thin basement membrane (Plate IV, Fig. 2). When viewed with reflected light under high power of the binocular microscope the outer surface has a cellular appearance due to the alveoli (Plate II, Fig. 2). The cellular layer on the dorsal side, especially near its junction with the ostiolar prominence, is thinner and has transverse wrinkles in it similar to the wrinkled surface of the reservoir. Surrounding the outside of each gland is a basement membrane which is a continuation of the basement membrane of the epidermis. Since the gland lies so close to the body wall there are no distinct ducts but simply two openings around which the gland wall continues into the epidermis of the dorsal abdominal wall (Plate IV, Fig. 2).

Tracheation of the Abdominal Glands.

The oxygen supply to the abdominal glands comes through the spiracular trunks which arise at the third, fourth and fifth abdominal spiracles (Plate I, Fig. 1). Connecting the three spiracular trunks are large longitudinal tracheæ which form a continuous line on each side of the abdomen From these longitudinal tracheæ ten small branches are given off, five of which go to each gland. Three of the five which supply the anterior gland pass up over it to the dorsal side while the other two go to the ventral surface. Only one of the five supplying the posterior gland goes to the ventral surface, the other four supplying the dorsal and lateral sides.

The large tracheal branches of the glands are located on the exterior surface but the very small branches and tracheoles pass down into the glandular tissue between the alveoli and spread out on the inner surface as a sort of coarse net work. As far as could be observed there were no tracheæ connecting with the intima.

Attachment of Muscles.

Since the glands are similar in size and shape, one would expect them to have the same musculature. Such, however, is not the case for there are two more muscles to the posterior gland than to the anterior one. There are fourteen muscles

which serve to operate the glandular mechanism of the abdominal glands. For convenience the writer has placed them in four groups according to their location as follows: lateral muscles, anterior muscles, posterior muscles, intermediate muscles, and interglandular muscles (Plate III, Fig. 3). There is a lateral muscle to each side of each gland which extends from the lateral edge of gland to the dorsal body wall (Plate II, Fig. 3). The anterior muscles, two in number, attach at their cephalic end to the conjunctiva between the third and fourth segments. The dorsal muscle which is the longer joins to the neck of the gland while the other attaches to the front edge of the anterior gland. Two of the three intermediate muscles extend between the two glands, being attached at the cephalic end to the posterior side of the neck of the anterior gland and at the other end to the opposite side of the neck of the posterior gland. The other intermediate muscle joins to the anterior side of the neck of the latter gland just in front of the other two muscles and extends to the posterior edge of the anterior gland. Two of the four posterior muscles extend from the conjunctiva between the sixth and seventh segments to the caudal side of the neck of the posterior gland. The other two are much shorter and extend from the same conjunctiva to the posterior edge of the gland where they are inserted one above the other. The interglandular muscle as the name suggests connects the two glands together. One end is inserted at the anterior edge of the posterior gland and the other on the ventral surface near the posterior end of the anterior gland. The muscles all taper somewhat at the ends to form a sort of tendon which serves as a means of attachment. Where a muscle is joined to a gland it passes through the alveoli, spreads out a little, and attaches between the alveoli and the chitinous intima. The dorsal anterior muscle, the two dorsal posterior muscles and the two dorsal intermediate muscles are paired being located on each side of the median line of the body in the region of the ostioles.

Nerve Supply.

The nerves in the nymph were even more difficult to trace out than those of the adult. A nerve was found arising from the ventral nerve cord and extending up over the abdominal gland (Plate I, Fig. 1), but its attachment to any organ could

not be definitely determined. Further research will be necessary to work out in detail the nerve supply which innervates the glandular apparatus.

Mechanics of Operation.

The valvular mechanism in the nymph is much simpler than that of the adult, there being no vestibule or chitinous arms. The gland walls in the nymph are attached to the body wall partly to the lateral side of the rim of the ostiole and partly to the edges of the chitinous leaves, which are projections from the dorsal wall extending in from the ostioles. The dorsal chitinous leaf (Plate IV, Fig. 1) extends across the ostiolar prominence between the ostioles and serves as a point of attachment for the anterior side of the neck of the gland (Plate III, Fig. 1). The ventral chitinous leaf extends only part way across and acts as a sort of valve to close the ostiole by lying against the dorsal leaf. When the liquid is ejected the muscle attached to the ventral leaf contracts and pulls the leaf away from the upper one (Plate III, Fig. 1) thus allowing the liquid to pass out between the leaves to the ostiole. The pressure necessary to force the liquid out is produced by a flattening action brought about by the lateral muscles (Plate II, Fig. 3) and the short muscles which are attached to the ends of the glands (Plate III, Fig. 3). The longer muscles attached to the necks of the glands serve to pull the neck apart since it is normally close together. Some pressure may be supplied by the dorso-ventral muscles which extend between the dorsal and ventral body walls of the abdomen (Plate II, Fig. 3).

Range and Manner of Ejection.

The nymphs even in the fifth instar apparently do not have the power to eject the glandular secretion as far as the adults. They are, however, as quick to eject the liquid when molested as the adults. As was the case with the adults, nymphs which had been captured and kept for a few hours did not readily discharge the liquid even when strongly irritated.

The same experiment which had been used to determine the range of ejection in the adult was tried with the nymph. It was found when the nymph was prodded that a small quantity of liquid was sprayed out laterally from the ostiole for a

distance of two inches. This experiment was repeated several times but in no case was the maximum distance more than two inches.

HISTOLOGY.

The metathoracic glands in the adult are of the convoluted tubular type consisting of a long much coiled tube and a duct leading to the reservoir. Although the glands are believed to be of ectodermal origin no chitinous intima was found in them. In a cross sectional view the coiled tube of a gland appears as a circular layer of cells inclosing a lumen (Plate IV, Fig. 4). In the lumen are large granules which are secreted by the surrounding cells and are believed to have some part in forming the liquid. The number of cells in a cross section of the tube varies somewhat but eight may be taken as the average number. The nuclei of these cells contain a nucleolus and there are granules in the cytoplasm.

The tissue composing the reservoir consists of a thin layer of cells containing nuclei which are some distance from each other. This layer is deeply wrinkled and folded especially in the posterior ventral part of the sac (Plate V, Fig. 1). The chitinous intima follows loosely the contours of the folds and is itself much wrinkled giving the tissue a very irregular appearance. The corrugated surface of the intima in the reservoir presents a condition similar to that found by Detwiler (1922) in the sac of the glandular apparatus of the Red-Humped Apple Caterpillar, *Schizura concinna* Smith and Abbot. Although Detwiler found fine canals extending through the intima the writer was unable to find similar structures in either the intima of the reservoir or the abdominal gland of the squash bug. The tissue composing the reservoir is not believed to have any secretory function.

There are four types of cells found in the glandular apparatus of the nymphs. They all develop from the ectodermal invaginations which form the glands in the embryo. The first type to be considered is that of the less specialized epidermal-like cells whcih surround the alveoli (Plate IV, Fig. 6). The second type is like the cells in the reservoir in the adult already described above. These cells compose a small section of the walls at the ends of the glands. A third type of cell is found in the large nucleated secreting cells in the alveoli (Plate IV,

Fig. 6). The nuclei are three or four times as large as those of the other cells in the gland. They contain many dark staining granules but no nucleolus was found. These granules are believed to be concerned with the formation of the secretion. The fourth type (Plate IV, Fig. 3) is found in the tissue making up the greater part of the dorsal wall of the abdominal glands. The cytoplasm of these cells stains with the eosin a clear brown which is believed to be due to some chemical either secreted by the cell or incorporated in the protoplasm. The cytoplasm is finely granular in nature and the nuclei are similar to those of the epidermal-like cells. These brown-staining cells are elongate and irregular in shape extending down into the gland for two or three times their width in some cases. The function of these cells is not clearly understood.

It is interesting to note that although the tissue of the reservoir has the same orange color of the dorsal part of the abdominal glands, it does not stain brown with the eosin.

Development of Glandular Apparatus.

The abdominal gland starts in the embroynic stage as a narrow ectodermal invagination. At three days before hatching the gland appears as a small transverse pocket leading in from the body wall and slanting forward somewhat. Near its inner end the pocket widens out, part of it extending forward parallel with the dorsal body wall and part of it extending posteriorly. The anterior extension is four to six times longer than the posterior one. The lumen of the gland at this stage is of about uniform width throughout, and this is approximately the long diameter of the nuclei of the cells in the gland wall The greater part of the cells resemble those of the epidermis except that the nuclei are more elongated than those of the latter. At the age mentioned above a few secreting cells with the large granular nuclei have already been differentiated. There are also several cells in the anterior end of the gland similar to those of the wall of the reservoir of the adult (Plate V, Fig. 1). The chitinous intima has already been developed at this stage.

Not much change takes place in the gland at hatching or during the first instar except that there are more secreting cells and an increase in the size of the lumen of the gland.

The gland at the end of the first instar reaches a size of .16-.17 millimeters. Although the molted glands are present in the cast skin of the first instar nymph, none were observed to secrete any liquid during the instar. In the second instar the brown staining tissue in the dorsal wall of the gland has appeared. The glands have also enlarged and filled out to some extent. During the successive instars up to the latter part of the fifth there is not much change in the abdominal glands except increase in size and the number of secreting cells. In the latter part of this instar, the glands begin to reduce in size and this reduction continues until the last molt at which time the glandular tissue has been almost completely absorbed, only a small amount of tissue being left in a ring around the base of the ostiolar prominence.

The metathoracic gland and the reservoir in the adult begin to develop during the fifth instar. At the beginning of the instar there is no evidence of either the glands or reservoir. The early development of the metathoracic gland has not been thoroughly worked out. During the latter part of the last instar the reservoir was found as a thin pad of tissue similar in outline to the reservoir of the adult but much smaller in size The dorsal and ventral sides were in close apposition and there was no liquid present or color to the tissue. The ventral nerve cord at this time passes over the reservoir in a shallow groove along the median line of its surface. As the sac matures and becomes filled with liquid the nerve cord is pushed to one side or the other and remains in that position throughout the life of the insect (Plate I, Fig. 2). The metathoracic glands are well formed a few days before the end of the last instar and differ from those of the adult only in size.

The reservoir in the newly emerged adult is still colorless and without any liquid in it. After the bug has fed the sac rapidly enlarges, fills with liquid and assumes its normal orange color. The remains of the ostiolar prominence which marked the openings of the nymphal glands show as transverse ridges much wrinkled at the interior part. There are two slightly raised tubercles above the vestigial ostiole but there is no distinct opening, merely two narrow reddish slits. Internally the dorsal part of the old glandular tissue with the orange color still present remains around the ostiolar prominence as the neck of the gland. The tracheal branches and tracheoles

which supplied the dorsal part of the old gland remain in the adipose tissue below the atrophied ostiolar prominence.

NATURE OF THE SECRETION.

The liquid which produces the offensive odor common to squash bugs secreted by both the metathoracic and abdominal glands consists of a volatile oil, very light yellow in color. The odor is suggestive of banana oil, amyl acetate, in both the adult and nymphs, but its odor is not exactly the same in both stages. The oil gives an acid reaction with litmus paper and has a very acrid taste, leaving a burning sensation on the tongue for several minutes.

FUNCTION OF THE GLANDS.

The function of the repugnatorial glands in the squash bug is believed by Kunckel (1866) to be protective. The irritating nature of the secretion would tend to discourage insectivorous birds and predacious insects from eating the bugs. It might be possible that the glands have an excretory function in ridding the body of certain waste products. Further research would be necessary, however, to clear up this point.

SUMMARY.

1. The glandular apparatus in the adult stage of *Anasa tristis* consists of two tubular glands in the metathorax which empty by ducts into a reservoir which in turn opens to the exterior through two ostioles located one on each side between the middle and hind coxæ.
2. The repugnatory glands in the nymphal stages consist of two glandular sacs lying just beneath the dorsal wall of the abdomen each opening to the dorsal surface of the abdomen by two apertures located between the fourth and fifth and the fifth and sixth segments.
3. The metathoracic glands in the adult do not develop from the abdominal glands in the nymph nor are they related in any way morphologically to them but they do, however, perform the same function.
4. The metathoracic glands develop during the last nymphal instar while at the same time the abdominal glands are atrophying.

5. At each molt the chitinous linings of the abdominal glands are pulled out and left intact with the liquid still in them in the cast skin.

6. Both glands and reservoir are of ectodermal origin being formed by invaginations of the body wall and having the cuticula, epidermis, and basement membrane of the body wall. The abdominal glands originate as ectodermal invaginations in the embryo. Some of the cells become differentiated into secreting cells before hatching

LITERATURE CITED.

Detwiler, J. D. 1922. The Ventral Prothoracic Gland of the Red-Humped Apple Caterpillar, Schizura concinna Smith and Abbot. Can. Ent., Vol. 54, pp. 175–191.

Dufour, Leon. 1833. Recherches anatomiques et physiologiques sur les Hemipteres. Mem. Savants Etrang. Acad. d. Sc., Paris, Tome 4, pp. 129–462

Kershaw, J. C. 1907. Life-history of Tessaratoma papillosa Thunberg. Trans Ent. Soc. London, 1907, pp. 253–255.

Kunckel, M. J. 1866. Recherches sur les organes de secretion chez de l'order des Hemipteres. Compt. Rend. Acad. d. Sc., Tome 63, pp. 433–436.

Tower, Daniel G. 1913 The External Anatomy of the Squash Bug, Anasa tristis De Geer. Ann Ent Soc. Amer., Vol. 6, pp. 427–441.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Median, longitudinal, vertical section of the abdomen of a nymph showing abdominal glands with their trachea and nerve.

a. ab. gl., anterior abdominal gland; n. gl., nerve to glandular apparatus; os. pr., ostiolar prominence; p. ab. gl., posterior abdominal gland; sp. tr., 3, 4, 5, spiracular trunks to third, fourth, and fifth abdominal spiracles; v. n. c., ventral nerve cord; 4, 5, 6, fourth, fifth and sixth abdominal segments.

Fig. 2. Dorsal view of a horizontal outline of the body of an adult male, showing nervous, tracheal and muscular systems of the glandular apparatus.

b. w., body wall; ch. a., chitinous arm; c. cv., 2, 3, second and third coxal cavities; d. r., duct to reservoir; m. gl., metathoracic gland; n. v. r., nerve to valvular muscle; res., reservoir; th. g., thoracic ganglion; t. res., trachea to reservoir; ts., testis; ves., vestibule; v. ms., valvular muscle; v. m., valvular membrane; v. n. c., ventral nerve cord; 2, 3, second and third thoracic segments; I, II, first and second abdominal segments.

PLATE II.

Fig. 1. Surface view of a small portion of a metathoracic gland.

tr., trachea; tu., tubule.

Fig. 2. Surface view of the secreting tissue of an abdominal gland.

al., alveolus; lu., lumen; tr., trachea.

Fig. 3. Transverse vertical section through an abdominal gland showing lateral muscles.

gl., gland; l. m., lateral muscles; d. v. m., dorso-ventral muscles; os. pr., ostiolar prominence.

Fig. 4. Ventral view of thorax of an adult.

a. sp., abdominal spiracle; c. cl., coxal cleft; c. 2, 3, coxa of meso- and meta-thoracic legs; e., epimeron of meso- and metathorax; es., episternum of meso- and metathorax; f. w., fore wing; ms. s., meso-sternum; mt. s., metasternum; os., ostiole; os. pr., ostiolar peritreme; pl., plerae of meso- and metathorax; pr. s., prosternum; 1, 2, 3, prothorax, mesothorax, metathorax, respectively; I, II, III, first, second and third abdominal segments.

Fig. 5. Dorsal view of the ostiolar prominence of a nymph.

l. s., scar of opening through old gland pulled out in molting; os., ostiole; os. c., ostiolar canal; os. gr., ostiolar groove

PLATE III.

Fig. 1. Longitudinal, vertical section through the chitinous leaves of the ostiolar prominence of a nymph.

b. m., basement membrane; ch., chitinous covering of body wall; ch. in., chitinous intima; ch. l., chitinous leaves; ep., epidermis; gl. w., gland wall; m., muscle.

Fig. 2. Median, horizontal, longitudinal section through the left vestibule of an adult.

ap., aperture from duct to vestibule; b. w., body wall; c. cv., coxal cavities of meso- and metathoracic legs; d. g., duct of gland; m. a. m., flattened extension of chitinous arm; os., ostiole; os. pr., ostiolar peritreme; p.t. sp., posterior thoracic spiracle; ves., vestibule; v. m., valvular muscle; vm., folded sheet of valve; w. res. d., wall of reservoir duct; 1, 2, 3, Chitinous arms.

Fig. 3. Median, longitudinal, vertical section of the abdomen of a nymph, showing glandular muscles.

a. gl., anterior gland; a. m., anterior muscles; in. gl. m., interglandular muscle; ir. m., intermediate muscles; p. gl., posterior gland; p. m., posterior muscles.

PLATE IV.

Fig 1. Transverse vertical section through ostiole of the abdomen of a nymph.

b. m., basement membrane; ch., chitinous covering of body wall; ch. in., chitinous intima; ch. l., chitinous leaves; ep., epidermis; gl. w., wall of gland; os., ostiole; os. gr., ostiolar groove.

Fig. 2. Transverse vertical section through ostiole of a nymph at the posterior edge of the chitinous leaves; abbreviations to parts same as in Fig. 1.

Fig. 3. Longitudinal vertical section through the dorsal wall of an abdominal gland of a nymph.

ch. in., chitinous intima; cy., cytoplasm; n., nucleus; nu., nucleolus.

Fig. 4. Cross-section of the tube of a metathoracic gland, highly magnified.

cm., cell membrane; cy., cytoplasm; gr., granules in secretion; lu., lumen; n., nucleus; nu., nucleolus.

Fig. 5. External view of left external orifice in an adult.

c. cl., third coxal cleft; dk., disk; ep., 2, 3, epimeron of meso- and metathorax; gr., grooves of vestibule; mes., mesothorax; met., metathorax; os., ostiole; os. p., ostiolar peritreme; p. t. sp., posterior thoracic spiracle.

Fig. 6. Longitudinal section through an alveolus of an abdominal gland of a nymph in the ventral part of gland wall.

c. in., chitinous intima; d., duct; lu., lumen; n. l., nucleus oflarge nucleated cell; n. s., nucleus of small nucleated cell; s. g., secreting granules.

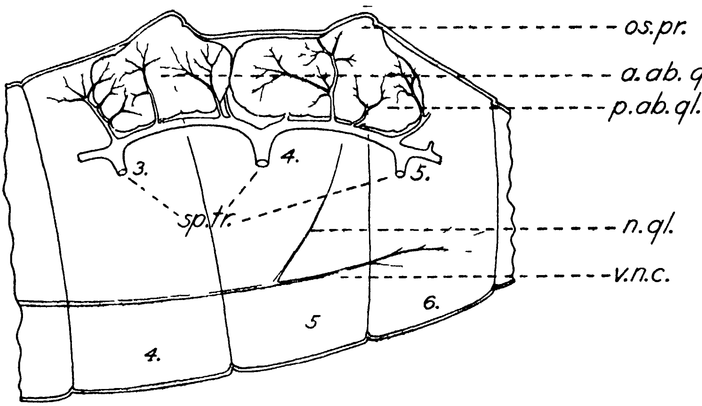
PLATE V.

Fig. 1. Longitudinal section through the ventral part of the body wall of a reservoir.

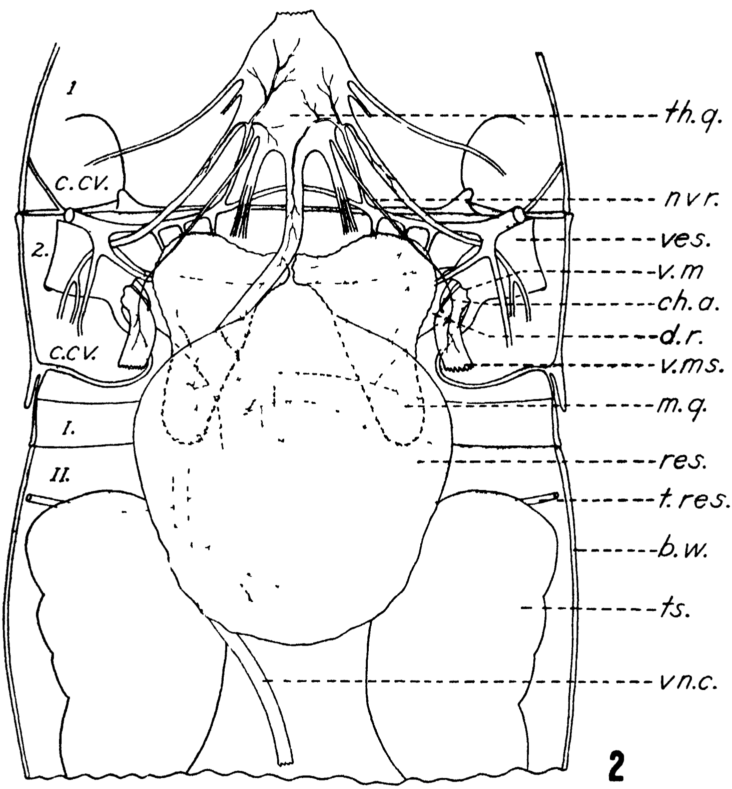
c. in., chitinous intima; i. r., interior of reservoir; n., nucleus; nu., nucleolus.

Fig. 2. View of glandular apparatus in the ventral part of the body of adult cut transversely through the ostioles.

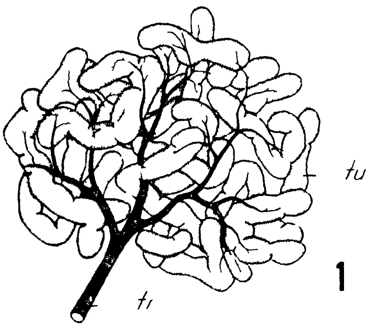
b. w., body wall; c. cl., coxal cleft; d. res., duct of reservoir; gl., gland; g. m., glandular muscle; h. c., hind coxa; os., ostiole; res., reservoir; ves., vestibule; v. m., valve membrane.


os.pr.
a. ab. gl.
p. ab. gl.
3.
4.
5.
sp. tr.
n. gl.
v.n.c.
4.
5
6.

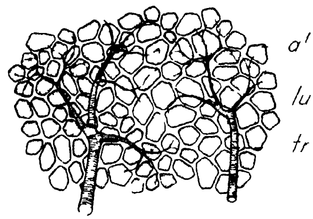
1


1
c. cv.
2.
c.c.v.
I.
II.
th. g.
n v r.
ves.
v. m
ch. a.
d. r.
v. ms.
m. g.
res.
t. res.
b. w.
ts.
v n.c.

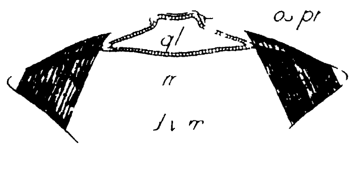
2



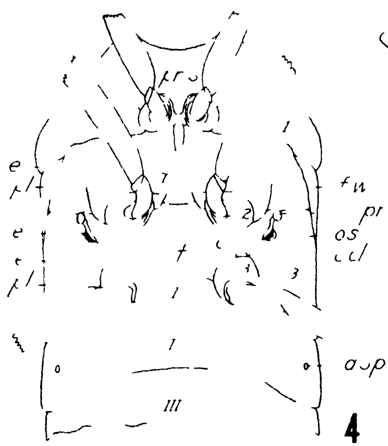
1



2

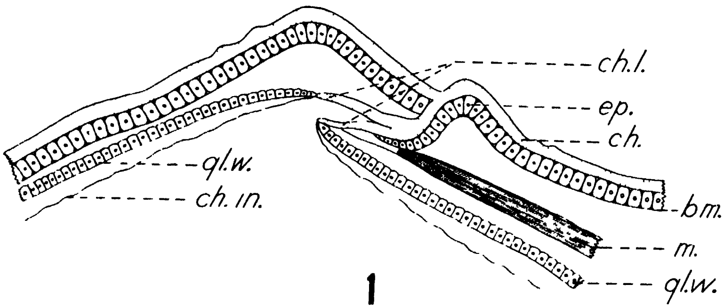


3

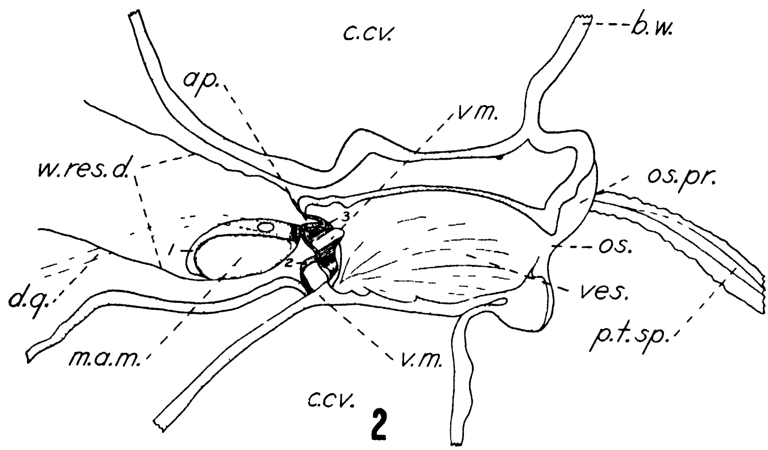


4

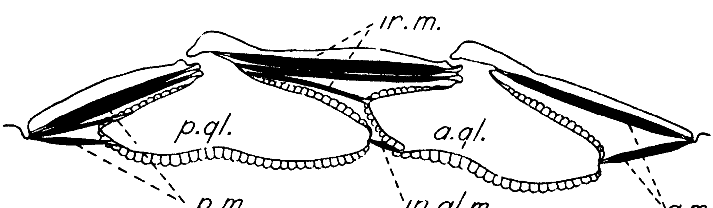
5


ch.l.
ep.
ch.
gl.w.
ch. in.
bm.
m.
gl.w.

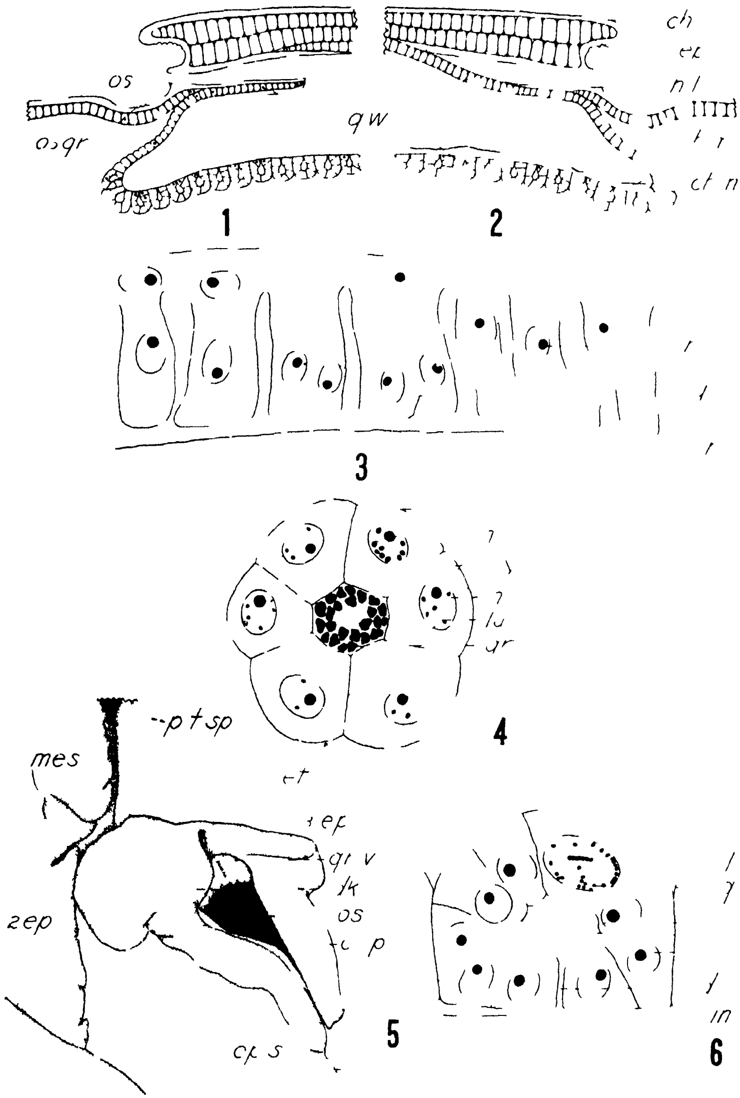
1

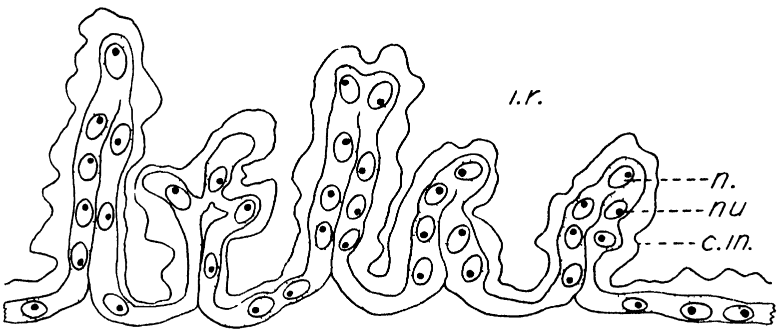

c.cv.
b.w.
ap.
v.m.
w.res.d.
os.pr.
1
2
3
os.
d.g.
ves.
m.a.m.
v.m.
p.t.sp.
c.cv.

2

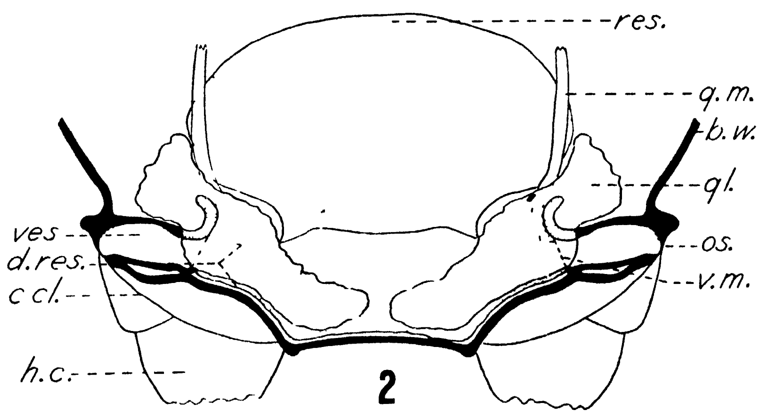

ir.m.
p.gl.
a.gl.
p.m.
ir.gl.m.
a.m.

3


os
gw
ch
mes
zep
os
1
2
3
4
5
6



1



2

SOME EFFECTS OF TEMPERATURE AND HUMIDITY AS FACTORS IN THE BIOLOGY OF THE BEDBUG (CIMEX LECTULARIUS LINN.).*

R. M. JONES.

INTRODUCTION.

The life-history of the Bedbug (*Cimex lectularius* Linn.) has been studied in widely separated localities, but not much attention was given to the factors of temperature and relative humidity. In the experiments recorded herein, the writer has used constant conditions of both temperature and relative humidity throughout the life-cycle of the insect.

A review of the literature shows that nothing has been published on the weight of the egg, of the different instar nymphs and the adult, and the amount of blood consumed at a "meal" and during the larval period. The incubation period of the egg and the survival of the nymph without food have been worked out in part by other investigators.

HISTORICAL.

In reviewing the literature the writer found only a few publications on the bedbug relating to the type of work presented in this paper. Many important papers have been written on this insect, but only those that relate directly to the writers work are cited here.

Girault (1912) found that the incubation period varied from 5 to 10 days at 28°–31°C.; the average hatch occurred in 6 to 7 days. At Runcorn, England, during the months of June, July and August, 1912, Blacklock (1912) observed that the incubation period averaged 17 days under laboratory conditions. He also states that when the temperature was increased to 22°C. the average incubation period was 14 days, while at 25°C. the length of time was decreased to 10 days.

Girault (1912) states that there was an average period of 6 days between molts under artificial conditions, but these were not given

*These studies were conducted in the Insectary, Iowa State College, Ames Iowa. The writer wishes to express his appreciation to Dr. C. J. Drake for guidance and supervision; thanks are also due Dr. C. H. Richardson, Mr. George C Decker and Mr. Roy Melvin for many suggestions and criticisms.

Under favorable conditions of food and temperature, Marlatt (1916) found an average period of about 8 days between molts, the molting periods being shorter in the earlier stages and longer in the later stages. This gave about seven weeks as the time required for the insect to reach the adult stage.

According to Girault (1910) if a bedbug is fed to repletion once in each instar, normal development occurs, though the bug will take additional meals in any one instar after an interval of several days. Marlatt (1916) also observed that ordinarily but one meal is taken between molts and under favorable circumstances additional meals may be occasionally taken.

Cragg (1923) found that eggs are not laid until the female has fed, although the male organs are functional and the female can be fertilized before the first meal in the adult stage.

Girault (1912) records the duration of life of first instar nymphs without food to be from 17 to 42 days under artificial temperatures, but these were not given. In his experiments with starvation of first instar nymphs, Bacot (1914) found the duration of life to be from 66 to 136 days at 15°–17°C. The average life was 108 days. The following data are also taken from Bacot's experiments:

1.	Temperature 24° C., humidity 65–70 per cent.	
	Average life	10 days
	Longest life	21 days
2.	Temperature 31° C., humidity 70–80 per cent.	
	Average life	7 days
	Longest life	11 days
3.	Temperature 35.5° C., humidity 25 per cent.	
	Average life	5 days
	Longest life	8 days

Marlatt (1916) states that young bedbugs, obtained from eggs, were kept in small sealed vials for several months, remaining active in spite of the fact that they had never taken any nourishment whatever. The conditions of temperature and relative humidity are not given.

METHODS.

The experiments presented in this paper have been conducted under constant conditions of temperature and relative humidity. Incubating ovens were used to obtain the desired temperatures and the relative humidities were kept constant by using saturated solution of certain inorganic salts. The per cent of relative humidity which a salt will give has been taken from Spencer, International Critical Tables (1926), with the exception of sodium bromide which was determined in the laboratory. An inorganic salt, of course, registers a different per cent of relative humidity at different temperatures. The

salts and the per cent of relative humidity that each will yield in excess in water between 13°—33° C. are given below.

Potassium acetate	19%
Magnesium chloride	31-35%
Sodium bromide .	55-65%
Sodium chloride . .	74 76%

The weight determinations presented in this paper were made on a Wm. Ainsworth and Sons Precision balance.

The eggs were obtained from bedbugs kept in small stender dishes in a glass battery jar under a constant condition of 27° C. and 75 per cent relative humidity. These bugs were fed every six days by being placed in wide mouth glass tubes and held against the forearm. The females laid their eggs on small circular pieces of paper toweling placed in the dishes for that purpose. At least once a day, or oftener when an experiment required an accurate record of the time the eggs were laid, the papers were taken out and the eggs removed with a camel's hair brush. They were then put in other jars under the same conditions and used for the experimental work as soon as they hatched.

The following method was employed in rearing the bugs. Short pieces of 8 mm. by 40 mm. glass tubing were ground to a roughened surface on one end by applying to an emery wheel. On this end was then glued a small circular piece of 60 mesh bolting cloth, the other end being closed with the cap of a No. 000 gelatin capsule in which holes were punched to allow free circulation of air. One egg was placed in each tube and this furnished the permanent home for the bedbugs. The cages containing the eggs were kept under the conditions as outlined above. After hatching the nymphs were permitted to feed by holding the tubes against the wrist, no difficulty being experienced by the nymph in inserting the rostrum between the meshes of the bolting cloth. By using this method it was not necessary to remove the bugs from the cages until after they had reached the adult stage. The jars were aerated each day by fanning in fresh air with a piece of cardboard.

In determining the length of time required for incubation the eggs were placed in 10 mm. by 50 mm. shell vials. These were then placed in 20 mm. by 80 mm. vials containing a saturated solution of the salt giving the desired relative humidity and tightly corked. The vials were also aerated once a day.

To determine the length of life of the first instar nymphs without food the nymphs were placed in No. 000 gelatin capsules in which many holes had previously been punched to allow a free circulation of air. The capsules were put in a small screen cage which was suspended in a pint Mason fruit jar containing a saturated solution of the salt giving the desired relative humidity. Aeration of the jars was performed daily as in the previous experiments.

LIFE HISTORY.

Egg.

The egg, at time of deposition, is pearly white, somewhat oval, the cephalic end being closed by a disc-shaped lid. Shortly before hatching it becomes light yellow and the red eyes of the developing nymph can be plainly seen through the chorion. The length is slightly more than twice its width, the average of one hundred eggs being 1.0178 mm. in length and .434 mm. in width. Under the conditions used in this experiment the average incubation period was found to be 5.9 days.

The method of hatching is similar to that found in many other Hemipterous insects. Nymphs escape from the eggs by opening the lid which covers the circular opening at the cephalic end with an inverted somewhat pyramidal-shaped structure called the lid-opener. This lid-opener or egg-burster is attached dorsally to the membrane which envelops the nymph before emergence. After the apparatus has performed its function it slips back over the head of the emerging nymph and remains attached to the membrane, usually within the egg-shell. The nymph gradually works its way out until the antennæ and legs are free. As soon as the appendages are capable of movement the nymph pulls the tip of the abdomen out of the egg shell and seeks a convenient hiding place.

Length of Instars.

The bedbug molts five times. The writer has found no records of more than five molts, although Marlatt (1916) states that conditions of famine and unfavorable temperatures may result in additional molts.

Under the conditions of 27° C. and 75 per cent relative humidity the lengths of the different stages in the bedbug were

5 days for the first instar, 4.5 days for second, 4 2 days for third, 4.6 days for fourth and 6 days for the fifth

TABLE 1

SUMMARY OF LIFE-HISTORY *

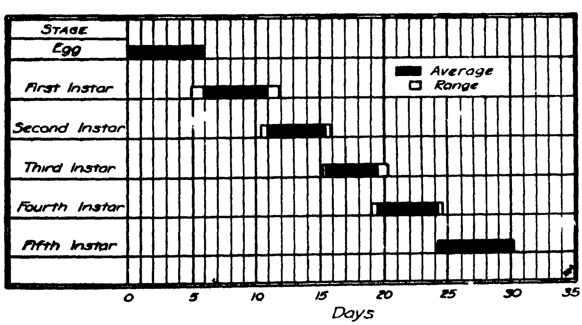
	STAGE						TOTAL AVERAGE DAYS
	Egg	1st	2nd	3rd	4th	5th	
Average days	5 9	5 0	4 5	4 2	4 6	6	30 2
Range in days	5 6—6 1	4–6	4–5	4–5	4–5	6	

Temperature 27° C. Humidity 75 per cent

An interesting and important point shown in the above table is a decrease in the number of days required between molts in the first three instars. The length of time required was about the same in the second and fourth instars, whereas the last instar required a longer period for development than

GRAPH 1

SUMMARY OF LIFE-HISTORY. (Fifty Bedbugs).



the others. Another interesting point is that the variations from the average time are not as great in the later instars as in the earlier stages, all requiring approximately the same length of time between molts in the fifth instar. These results are also presented in Graph 1.

*Results based on records of fifty individuals reared from egg to adult stage.

Nymphal and Adult Stages.

Newly hatched nymph white, nearly transparent, becoming light yellow within a few hours; the characteristic brown color of the more mature stages increasing with each molt. Engorged nymph enlarged, elongated, and brightly colored from the ingested blood Body outline oval and slightly convex. Eyes dark brown, located on side of head Antennæ 4-segmented,

TABLE 2

MEASUREMENTS OF NYMPHAL INSTARS AND ADULT STAGE

	STAGE					
	First	Second	Third	Fourth	Fifth	Adult
Length before feeding	1 2 mm	1 8 mm	2 03 mm	3 07 mm	4 2 mm	5 5 mm
Width before feeding	696 mm	1 02 mm	1 28 mm	1 97 mm	2 3 mm	3 0 mm
Length after feeding	1 74 mm	2 2 mm	2 7 mm	4 06 mm	4 95 mm	7 5 mm
Width after feeding	754 mm	1 16 mm	1 5 mm	1 74 mm	2 1 mm	2 7 mm
Length of antenna Segment I	056 mm	058 mm	06 mm	087 mm	12 mm	15 mm
Segment II	145 mm	2 mm	261 mm	38 mm	45 mm	63 mm
Segment III	232 mm	31 mm	38 mm	49 mm	6 mm	69 mm
Segment IV	261 mm	36 mm	4 mm	4 mm	48 mm	51 mm
Total length of antenna	722 mm	928 mm	1 14 mm	1 4 mm	1 7 mm	1 98 mm
Total length of rostrum	3 mm	46 mm	52 mm	67 mm	75 mm	9 mm

densely pubescent, first two segments slightly thickened Body sparsely clothed with short hairs, those on outer margins being somewhat longer Rostrum 3-segmented Legs rather stout, pubescent, light yellow Females of the first instar may be distinguished from the males by the presence of minute genital characters on the abdomen by examining specimens mounted in balsam.

The general characters of the later instars do not differ greatly from those of the first instar, except the increase in

size. The adult stage is, however, characterized by the appearance of the rudimentary wing pads. These measure 1 mm. in length and .6 mm. in width. The head and thorax are more punctate than in the fifth instar; the abdomen is also slightly punctured. The measurements of the five instars and the adult stage are given in Table 2.

Imago.

The precopulation period is short, mating usually taking place within a few minutes to an hour after the first feeding Occasionally, however, pairs have been observed copulating before having fed.

The method of copulation has been very well described by Cragg (1914). The length of time the bugs remain in copulation varies from a few minutes to half an hour.

TABLE 3

NUMBER OF EGGS LAID BY UNFED FEMALE BEDBUGS

LOT NO	NO FEMALES	NUMBER OF EGGS LAID EACH DAY					TOTAL NO EGGS LAID
		1st	2nd	3rd	4th	5th	
1	6	13	15	7	2	0	37
2	4	8	10	5	2	0	25
3	3	8	9	4	1	0	22

Under 27° C. and 75 per cent relative humidity the preoviposition period was shortened somewhat over that reported by other investigators. Girault (1914) found that gg production began within 4 to 8 days after copulation, whereas the writer observed that never more than 3 days were required if the bugs were allowed to feed soon after the last molt

Contrary to the statement of Marlatt (1916) and Cragg (1923) the writer found that the female bedbug will lay eggs before feeding in the adult stage. Egg deposition usually begins within 5 to 6 days after fertilization and continues for 3 or 4 days without the female ever feeding, the majority being laid on the first two days. The observations recorded on three lots, see Table 3, were taken on specimens reared under

a constant condition of 27° C. and 75 per cent relative humidity.

The males and females of all stages require from 5 to 10 minutes to engorge with blood. They then hide away in some secluded and convenient place for a period of from 5 to 10 days for the digestion of their enormous meal. During this time they will not feed, the time being occupied with digestion of the blood, coition and deposition of the eggs by the female. Observations made during other experiments indicate that the female feeds more frequently than the male.

Eggs.—Size and Weight.

Size: With the aid of a calibrated binocular microscope one hundred bedbug eggs were measured to determine the variations in the length and width. The majority of the eggs conformed closely to the average measurements given in the table. However, some eggs were short and thick, whereas others were longer and more slender.

TABLE 4.

SIZE OF EGGS.

NUMBER OF EGGS MEASURED	DIMENSIONS	RANGE (in mm.)	AVERAGE (in mm.)
100	Length...	.966–1 073	1.0178
	Width	.355– .493	.434

Weight: One hundred eggs were carefully removed from the paper toweling on which they were deposited and weighed. The total weight was .0158 gram, giving an average of .000158 gram per egg.

Incubation Period.

As previous incubation records had been taken from experiments conducted under variable conditions the writer repeated this phase under conditions of constant temperature and relative humidity. The effect of temperature upon the period of development of the egg is given in Table 5. The range in number of days required for incubation varies with the temperature, the greatest variation occurring at the lower temperatures.

TABLE 5

INCUBATION PERIOD OF EGGS

TEMPERATURE	RELATIVE HUMIDITY	NO. OF EGGS	HATCHED		INCUBATION PERIOD, DAYS	
			Number	Per Cent	Range	Average
15° C	75%	50	50	100%	21.3-23.4	22.5
23° C	75%	50	50	100%	10.4-11.8	11.0
27°C	75%	50	50	100%	5.6-6.1	5.9
30°C	75%	50	50	100%	4.8-5.4	5.0
33°C	75%	50	50	100%	4.3-4.8	4.5

Duration of Life of Nymphs Without Food

Five hundred nymphs (see Table 6) were secured from eggs which had been incubated under a constant condition of 27° C and 75 per cent relative humidity to determine the length of life of the newly hatched nymphs without food under a wide range of controlled conditions of temperature and relative humidity. None of the five hundred fasting nymphs were able to attain the second instar without food.

TABLE 6

DURATION OF NYMPHAL LIFE WITHOUT FOOD

No. of Nymphs	Temp.	Relative Humidity	Length of Life in Days		
			Minimum	Maximum	Average
25	13°C	19%	24	84	62.6
25	13°C	34%	28	100	72.4
25	13°C	65%	80 (a)*		
25	13°C	76%	87 (b)		
25	23°C	19%	21	30	25.5
25	23°C	33%	23	57	38.5
25	23°C	62%	52 (c)		
25	23°C	75%	30 (d)		
25	27°C	19%	15	25	18.1
25	27°C	33%	17	29	21.6
25	27°C	60%	18	44	30.0
25	27°C	75%	22	48	32.0
25	30°C	19%	11	16	12.2
25	30°C	33%	11	17	13.4
25	30°C	57%	12	28	20.4
25	30°C	75%	22	36	27.7
25	33°C	19%	5	14	9.6
25	33°C	32%	7	16	11.0
25	33°C	55%	13	26	16.5
25	33°C	74%	17	35	24.6

*(a) Two dead at end of 90th day
(b) One dead at end of 91st day
(c) Fourteen dead at end of 85th day
(d) Twelve dead at end of 86th day

Weight of Bedbugs.

The average weights of the bedbug, before and after feeding, are given in the table below.

TABLE 7.

WEIGHT OF BEDBUGS

	Stage					
	1st	2nd	3rd	4th	5th	Adult
No of individuals	50	50	50	50	50	50
Average weight before feeding, in grams	00014	00029	00078	0014	0029	006
Average weight after feeding, in grams	0012	0019	0034	0059	0124	0255

Blood Consumed During Nymphal Stages.

To determine the amount of blood the bedbug consumes at each "meal" and during the entire growing period from the time of hatching until the adult stage is attained twenty newly hatched nymphs were placed in separate cages and reared to the adult stage under constant conditions of temperature and relative humidity. Each bug was fed the day following hatching, the day following molting in the different instars and was also given an opportunity to feed every third day after the first feed in each instar. In most instances the nymphs fed but once during each instar However, there were two exceptions, nymphs number 8 and 9 each fed twice during the third instar The amount of blood consumed by each nymph is tabulated in Table 8.

The twenty individuals discussed in Table 8 hatched on March 21 and molted (1) March 26, (2) March 31, (3) April 5, (4) April 11 and reached the adult stage April 17. Hence, under constant conditions of temperature, relative humidity and food all the twenty nymphs, except numbers 8 and 9, required approximately 5 days for the first instar, 5 days for second, 5 days for third, 5 days for fourth and 6 days for the fifth, or a total of 26 days to reach the adult stage.

TABLE 8.
AMOUNT OF BLOOD CONSUMED DURING NYMPHAL STAGES.
(Temperature 27° C ; Humidity 75%).

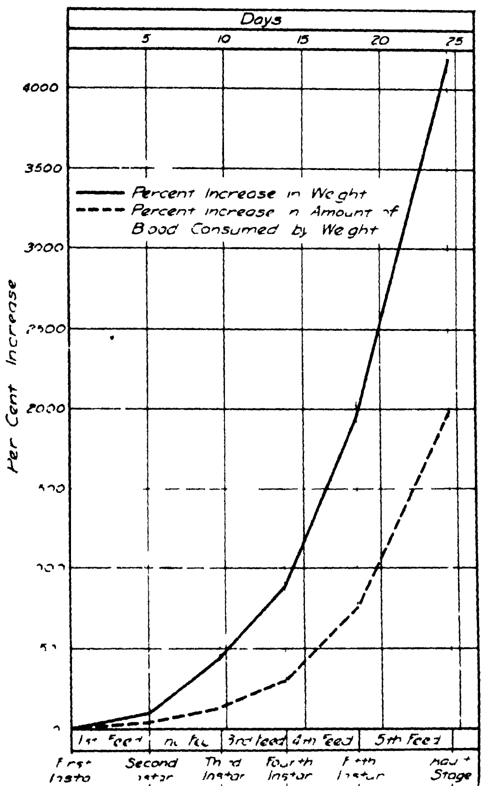
NYMPH NO.	INSTAR					TOTAL AMOUNT IN GRAMS
	1st	2nd	3rd	4th	5th	
1	0014	0017	0024	0053	0106	0214
2*	0008	0011	0015	0038	0078	0150
3	0009	0015	0025	0057	0096	0202
4	0010	0016	0020	0044	0101	0191
5	0009	0015	0016	0040	0083	0163
6	0008	0015	0032	0042	0105	0202
7*	0007	0010	0013	0028	0069	0127
8 (a)	0015	0017	0016 0029	0066	0108	0259
9 (a)	0016	0018	0014 0019	0039	0100	0206
10*	0012	0023	0020	0035	0095	0185
11*	0007	0014	0017	0030	0074	0142
12	0017	0022	0028	0048	0105	0220
13	0009	0016	0021	0044	0104	0194
14*	0010	0015	0017	0039	0093	0174
15	0016	0018	0024	0049	0090	0197
16	0013	0018	0022	0058	0100	0211
17	0008	0014	0029	0055	0103	0209
18	0016	0020	0026	0048	0098	0208
19*	0009	0013	0018	0033	0087	0160
20	0018	0023	0031	0063	0110	0245
Avg. of 6♂	0009	0014	0017	0034	0083	0156
Avg of 14♀.	0013	0017	0029	0050	0101	0209
Avg ♂ and ♀	0011	0016	0026	0045	0095	0193

* Male bedbugs
(a) Nymphs number 8 and 9 each fed twice during the third instar, the day following molting and again on the third day

The variations in the amount of blood consumed by the immature bedbugs seem to be due largely to the variations in size of the different individuals. The nymphs were allowed to feed without interruption until engorged and apparently satisfied The results show that, as a rule, the female nymphs

GRAPH 2.

Relative Per Cent Increase in Weight and in Amount of Blood Consumed by Nymphs



generally consume more blood during the period of growth than the male.

The ratio between the relative per cent increase in weight and in the amount of blood consumed, by weight by the nymphs in the different instars is shown in Graph 2 This graph is based on the results presented in Tables 7 and 8 and shows quite distinctly the approximate ratio between the increment

of growth and increment of blood consumption. The relative increase in the amount of blood consumed by the mature bedbug is based only on the first feeding after the adult stage is attained. The relative per cent increase in growth is increasingly greater than the relative per cent increase in the amount of blood consumed, particularly in the later stages.

The experiments presented in this paper were conducted during the winter and show conclusively that the bedbug will reproduce throughout the year under certain conditions. In the fall some female bugs, under room conditions, stopped laying after the weather turned cold. About two months later these bugs were placed in an incubator at 27° C. and 75 per cent relative humidity. Egg deposition was resumed by all the females in 5 to 6 days and continued regularly throughout the rest of the winter. The bedbug does not hibernate during the winter when the temperature, relative humidity and food conditions are suitable for continued activity. According to Marlatt (1916) the activity is at its greatest between 60° and 98° F.

Summary.

1. Fifty adult bedbugs were reared from the egg under a constant condition of 27° C. and 75 per cent relative humidity. The average time required for the different stages were; incubation period 5.9 days, first instar 5 days, second instar 4.5 days, third instar 4.2 days, fourth instar 4.6 days and the fifth instar 6 days. The average time required to reach the adult stage was 30 2 days. The length of the second and third nymphal stages was always shorter than the first. The variations from the average time required in each instar was not as great in the later instars as in the earlier stages.

2. The preoviposition period of the adult, the incubation period of the eggs, and the developmental period of the nymphs showed considerable variation under room conditions, but remained relatively constant at uniform temperature and relative humidity.

3. Contrary to other investigators it was found that the female will lay eggs before feeding in the adult stage.

4. Temperature and relative humidity are important factors in the incubation period of the egg and the duration of life of nymphs without food The length of life varies inversely

with the increase in degrees of temperature above 13° C. Relative humidities below 50 per cent cause death of the nymphs in less time than those between 50 and 75 per cent.

5. The amount of blood consumed at a "meal" and during the entire growing period was ascertained. The bugs usually fed but once in each instar and the variable amounts consumed were due largely to the difference in size of the individuals. The increase in weight of the nymphs in the different instars was slightly greater than the increase in the amount of blood consumed.

6. The size and weight of the egg, weight of the different stages, and the measurements of the five instars and the adult stage are presented in this paper.

7. The bedbug does not hibernate during the winter when the temperature, relative humidity and food conditions are suitable for continued activity.

LITERATURE CITED

Bacot, A. W. 1914 Influence of temperature, submersion and burial on the survival of eggs and larvae of Cimex lectularius. Bull. Ent. Res., Vol. v, pt. 2, pp. 111-117.

Blacklock, B. 1912 On the resistance of Cimex lectularius to various reagents, powders, liquids and gases. Ann. Trop. Med. and Parasitol., Vol. vi, no. 4, pp. 415-428.

Cragg, F. W. 1923 Observations of the bionomics of the Bedbug, Cimex lectularius Linn., with special reference to the relation of the sexes. Indian Jour. Med. Res., Vol. xi, no. 2, pp. 449-473.

Girault, A. A. 1910 Preliminary studies on the biology of the Bedbug, Cimex lectularius Linn., I. Jour. Econ. Biol., Vol. v, pp. 88-91.

1912 Preliminary studies on the biology of the Bedbug, Cimex lectularius Linn., II. Jour. Econ. Biol., Vol. vii, pp. 163-188.

Marlatt, C. L. 1916 The Bedbug. U. S. D. A. Farmers Bull. 754.

Spencer, Hugh M. 1926 Laboratory methods for maintaining constant humidity. International Critical Tables of Numerical Data, Physics, Chemistry and Technology. Vol. 1, pp. 67-68. (Published for the National Research Council by the McGraw-Hill Company.)

CONCERNING VELIA INVERUGLAS KIRKALDY AND RELATED FORMS. (VELIIDÆ-HEMIPTERA).

H. B. HUNGERFORD,
University of Kansas, Lawrence.

There are several closely related species of South American Velias that resemble superficially the *Velia rivularum* Fabr. and *Velia currens* Fabr. forms of Europe more closely than any of the other Velias of the western hemisphere. These western forms possess certain structural characters in common that set them apart from the European Velias and indeed from the western groups which I have listed in another paper. This group I have called the *Velia inveruglas* Kirkaldy group and have assigned to it the following: *Velia boliviana* Breddin, *Velia albotrimaculata* Kirkaldy, *Velia osborniana* Kirkaldy (= *V. brunnea* Osborn) and my *Velia helenæ*. The last one tentatively, because I do not know the male.

I have examined the types of all except *Velia boliviana* Breddin, which appears to have been lost. Breddin described this species from a single female which he said was in his own collection. I have seen that part of his collection which was received by the Deutsches Entomologisches Museum in Berlin-Dahlem and failed to discover this specimen. Nor did I find it in other European museums in which I worked. It is my understanding that a portion of Dr. Breddin's collection is not now extant.

It is unfortunate that Breddin's type cannot be examined. *Velia boliviana* Breddin (1898) was the first of this group to be described and came, of course, from Bolivia. The others are in order:

Velia inveruglas Kirkaldy (1899) Ecuador

Velia albotrimaculata Kirkaldy (1899) Venezuela

Velia osborniana Kirkaldy (1909). Bolivia This is a new name for *Velia brunnea* Osborn, 1904, because Doctor Osborn's name was preoccupied by *Velia brunnea* Horvath (1898). Doctor Horvath's species is now recognized as a synonym of *Velia noualhieri* Puton

Velia helenæ Hungerford (1929). Peru. This species is smaller than the others and readily distinguished by its orange-red head and pronotum. It presents the three white spots on the closed hemelytra as does *Velia albotrimaculata* Kirkaldy, but they are irregular in outline.

The pronotum is not so long and pointed behind. The insect is shorter in length and does not have the pale annulations on the legs as in *Velia albotrimaculata* Kirkaldy.

Velia albotrimaculata Kirkaldy.

Velia albotrimaculata Kirkaldy was described from a female in the Royal Museum at Brussels where, through the kindness of Doctor A. Ball, I had the pleasure of examining it. This species is also distinctly different from the earlier species described in this group. The type bears the labels "♀ type," "Coll. Camille Van Volxem." The antennæ are entirely gone. The following notes and the drawings submitted with this paper may assist in the recognition of this species for the original description is not accurate in certain particulars.

Size: Length, 8.2 mm; width across head, 1.25 mm; width across humeri, 2.6 mm. (Kirkaldy gives length, 7 mm; width, 3 mm.).

Color: Head and pronotum dark; covered with a "frost" which shows more in some lights than in others. Anterior half of pronotum carinate; surface of pronotum pitted. The three white spots on the hemelytra (folded) nearly round. Underside of thorax dark, of abdomen faintly orange-brown. Coxæ, trochanters, a ring near the base on the legs, pale lemon, nearly horn in color. (See Plate I. Figures 12 and 13).

Structural Characteristics: In connection with the original description it should be noted that the pronotum is long and pointed behind. The hind femora are not conspicuously "stout" when compared with some other Velia and they are provided with six stout spines of equal length on the distal three-fifths of the rear margin. No stridular area on the femora

An examination of the types of *Velia inveruglas* Kirkaldy and *Velia brunnea* Osborn revealed such structural resemblance that I have felt impelled to make a critical study of them and such other specimens as appeared might be one or the other of these forms. This has resulted in the recognition of two new species which will be described below.

For the benefit of students who may be interested in the Velia, I will first present some notes on the type of *Velia inveruglas* Kirkaldy.

Size: Length, 7.2 mm.; width across head, 1.26 mm; width across humeri, 1.8 mm.

Color: This apterous type is chocolate brown with grayish frost-like surface. Pronotum not margined by a different color. Legs also chocolate brown. The abdomen is covered with golden brown hairs

sparser above than below. Ten smooth, shiny, black spots showing plainly on side of the abdomen. The round ones near middle of segment, the others transversely elongate and located just behind the intersegmental lines—thus the round spots alternate with the long ones. (On other specimens of this group there are twelve such spots and probably also on the type, but they do not show plainly.)

Structural Characteristics: The type is an apterous male. The vertex of the head with a deep pit behind a middle line drawn between the eyes and a little nearer the inner margin of the eye than the median longitudinal line. Antennal formula: 1st : 2nd : 3rd : 4th : : 7 : 5.3* : 5 † : 5.6.

First antennal segment not much incrassate and its tip surpassing rear margin of the eye. Front femora slightly indented on anterior margin. Hind femora and tibia are longest, the femora unarmed or incrassate. Front tibia : front femur : : 11 : 11 ; middle tibia : middle femur : : 13.5 : 13; hind tibia : hind femur : : 20 : 15. (In the above measurements I used the greatest length of the femur.) Front tarsus is .95 mm. long the third segment longest; the middle tarsus is 1.5 mm. long, the first segment .3 mm., the second .5 mm., the third .7 mm ; the hind tarsus is 1.7 mm. long, the first segment .2 - mm. the others equal in length. (In the above I have used the greatest length of the third tarsal segment.) I find difficulty in understanding Doctor Kirkaldy's description: "Anterior tibia one-tenth longer than the femur, and twice as long as the second, which is twice as long as the first. Intermediate tibia one-fifth longer than the femur and one-fourth longer than the tarsus, third tarsal segment one-half longer than the second, the latter three and one-half times longer than the first. Posterior tibia one-half longer than the femur, and two and one-third longer than the tarsus, second and third tarsal segments subequal, each about four and one-half times as long as the first."

Prothorax is constricted in the middle and on the anterior part of the pronotum there is an oblique depression either side of the median carina. Rear margin of pronotum semicircular. The connexivum is rather broad, the width a little more than half the dorsum, and nearly erect. The caudal end of connexivum produced about one-third the length of the last abdominal segment and not sharply pointed. The dorsum of the last abdominal segment (preceding the genital segments) with a depression on either side. The last ventral abdominal segment is faintly tricarinate, the median ridge being slightly produced beyond the rear margin. Last genital segment slightly emarginate at dorso-distal margin. Genital segments more hairy than other parts of the body. A strong pit on each coxa, beneath and near the distal margin. No stridular area visible on hind femora or margin of abdomen. For drawings see Plate I, Figures 9 and 11.

*Not counting the small intersegment.

†Counting the small intersegment between 2nd and 3rd.

Velia osborniana Kirkaldy = **Velia brunnea** Osborn.

Doctor Herbert Osborn kindly sent one of his paratypes for examination. I find that the male genital claspers are very close to *Velia inveruglas* Kirkaldy. The antennal formula of the male sent to me by Doctor Osborn follows: 1st:2nd:3rd:4th: : 9:7.5:5.5:7. The suranal plate hooks appear to be a little longer than in Kirkaldy's wingless *V. inveruglas.* I have, however, a small series of specimens from Marcapata, Peru, in which the wingless male hooks have a spread of only three-fifths that of the winged form. It may be that the winged forms have longer hooks than the wingless. I believe that certain specimens with the humeri and entire surface of pronotum back of them orange-yellow belong to this species which, typically, has only the margin of the pronotum behind the humeri pale; one such specimen comes from Chaco, Bolivia, and belongs to the Museum at Stockholm.

Velia boliviana Breddin.

The measurements given by the author fit very closely some of the specimens above and may apply to those with the large orange-yellow areas on the pronotum. It is certain that this species and the two above are exceedingly close. Those described below are new.

Velia flavomarginata species new

Size: Length, 8.4 mm; width of head, 1.6 mm; width across humeri, 2.8 mm

Color: General color nearly black, including antennæ and legs. Pronotum margined all around with an orange-yellow band. Margin of connexivum also orange-yellow

Structural Characteristics: Head, with vertex short nearly flat, front of moderate length. Front margin of pronotum narrower than the head Antero-lateral margins diverging to the humeri, but markedly constricted in the middle. Median longitudinal carina present; disk of pronotum higher than the humeri which are elevated Portion of pronotum behind the middle of the humeri plainly longer than that in front; rear margin broadly rounded. Connexivum ending caudally in a stout sharp projection, longer than last dorsal abdominal segment Only two antennal segments present on any of the four specimens, formula for them: 1st : 2nd : : 8 : 7.

Hind legs longest and about equal in diameter. Distal tarsal segment of front and middle legs longest; middle tarsal segment of hind legs longest. Suranal plate hooks of male short, flat, inconspicuous. Clasper as shown in figure.

Described from four specimens (two males and two females), three of which are winged. They bear the following label: "Cardil[re] centr. (Colombie) Passo del quintio Dr. O. Thieme, 1877." Types in the British Museum.

Velia columbiensis species new.

Size: Length, 9 mm.; width across the eyes, 2—mm.; width across the humeri, 2.4 mm. in the apterous form; width across the widest part of thorax 2.8 mm.

Color: Body black, rear margin of pronotum orange-yellow Head and lateral margins of pronotum clothed with silvery pubescense. Golden pubescence on abdomen, most pronounced on the connexivum. Antenna and legs brown.

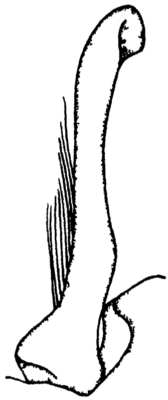
Structural Characteristics: Related to preceding species but having connexivum produced caudally but very slightly. Pronotum behind the median line of humeri little if any longer than that in front. Disk of pronotum not higher than the humeri. Antennal segments and legs relatively shorter than in preceding species. Only two antennal segments remaining on the two specimens at hand: 1st : 2nd : : 7.5 : 6.5, in the female. In the male the first segment is longer. The suranal plate hooks and the claspers of the male as shown in the figures. (Plate I. Figs. 3 and 4).

Described from two wingless specimens, a male and a female, from Columbia. The male bears the label, "Columbia Goudot Coll. 1846–20."

EXPLANATION OF PLATE I.

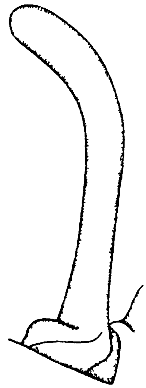
Concerning *Velia inveruglas* Kirkaldy and Related Forms.
(Veliidæ-Hemiptera).

Fig. 1. Left genital clasper of male *Velia inveruglas* Kirkaldy showing it in as flat a view as possible.
Fig. 2. Suranal plate hooks on male of *Velia flavomarginata* sp. new
Fig. 3. Suranal plate hooks on male of *Velia columbiensis* sp. new.
Fig. 4. Left genital clasper of male of *Velia columbiensis* sp. new. Same view as in Figure 1.
Fig. 5. Suranal plate hooks on male of *Velia inveruglas* Kirkaldy. Specimen of my determination.
Fig. 6. Suranal plate hooks on male of *Velia osborniana* Kirkaldy (= *Velia brunnea* Osborn) drawn from a paratype.
Fig. 7. Side view of male genital segments of the paratype of *Velia brunnea* Osborn. Shows the hook on the suranal plate and the left clasper.
Fig. 8. Left genital clasper of male of *Velia flavomarginata*.
Fig. 9. Sketch of the type of *Velia inveruglas* Kirkaldy sp. new. (Dorsal view) I have shown both the suranal hooks and claspers.
Fig. 10. Rear view of the tip of *Velia brunnea* Osborn paratype.
Fig. 11. Side view of the male genital segment of the type of *Velia inveruglas* Kirkaldy. In this sketch I did not show the suranal hooks. At the right is a free-hand sketch of the tip of the clasper seen from the rear. Another view of this clasper would look like Figure 1.
Fig. 12. Hind leg of the type of *Velia albotrimaculata* Kirk.
Fig. 13. *Velia albotrimaculata* Kirkaldy—sketch of type in Brussels Museum.


1 Velia inveruglas

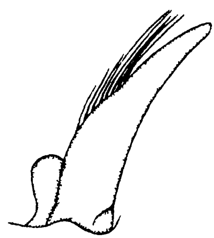

2 Velia flavomarginata


3 Velia columbiensis

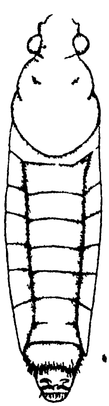

4 Velia columbiensis


6 Velia osborniana


5 Velia inveruglas


8 Velia flavomarginata

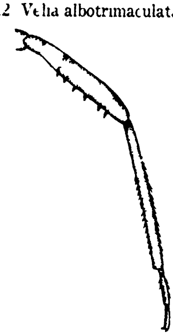

7 Velia osborniana

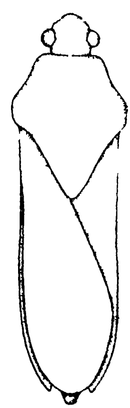

9 Velia inveruglas.


10 Velia osborniana


11 Velia inveruglas

12 Velia albotrimaculata




13 Velia albotrimaculata

OBSERVATIONS ON THE BIOLOGY OF PROTORTONIA PRIMITIVA (COCCIDÆ).

FRANZ SCHRADER,
Bryn Mawr College, Bryn Mawr, Pennsylvania.

The problem of the interrelationship of the various forms of Coccidæ still presents so many questions that any generalization on the broader aspects of their phylogeny still rests on a very insecure basis. It is true that in recent years the taxonomy of the group has been attacked with a fresh vigor, but most of the work of the systematists has naturally been concerned only with the external morphology. So far as such studies admit, there seems to be common agreement that the most generalized of the Coccidæ, and those perhaps closest to an ancestral type, are represented by the Monophlebinæ (or more comprehensively the Margarodidæ of Morrison, '28). Any further light thrown on that family especially is therefore of interest and it is with that justification that the present study of the life cycle of one member of the group is given.*

GENERAL OBSERVATIONS.

The form under consideration is *Protortonia primitiva*. It was collected during the early part of the years 1928 and 1929 at the following localities in Guatemala: Antigua, Guatemala City, and Salama. The host plant is *Urera baccifera*, the chichicaste of the Indians, which is much used as a hedge plant and is very effective in keeping enclosed areas inviolate because of its virulent stinging hairs. Not as large as some other members of the family, *Protortonia primitiva* nevertheless attains a respectable size, the adult female reaching a length of 8 mm. The colors of the living specimen are black and fiery red, so that despite the fine coating of waxy secretion that covers the body soon after the molts, the insects are rather conspicuous.

In none of the collection localities was the host plant heavily infected. Moreover, the occurrences were sporadic, so that

*I am indebted to Dr. Harold Morrison for the identification of the coccid, and to Dr. P. C. Standley for the identification of its host plant. To Senor A. Gebhardt, of Salama, Guatemala, I give my thanks for a generous hospitality as well as aid in the field work.

while certain plants in a hedge might carry a colony of the insects, adjoining plants were not infected. It may be mentioned in this connection that such a comparative scarcity is shared by many other Margarodidæ and most collectors will bear me out on that point. So far as *Protortonia primitiva* is concerned, no good explanation of this finding is available. There can be no competition for food in the species, for there is no dearth of the host plant. Moreover, the stinging hairs of the plant must protect the insects from many of their larger enemies. On the other hand, this protection is of course of no avail against predaceous Coleoptera and parasitic Hymenoptera, and enemies of these types were indeed encountered in small numbers. But so far as field observations go, enemies of this kind were not present in large enough numbers to constitute a decisive factor in the scarcity of Protortonia, although it must be stated that this conclusion rests on no systematic and detailed study. Two other factors should be mentioned. One is the comparatively small size of the broods of the individual females, while the other lies in the conditions of mating, as is pointed out below.

MATING.

Copulation occurs readily if both the male and female are at the right stage and in good condition. Unlike the females of certain other Coccidæ, that of *Protortonia primitiva* does not mate until after the third molt, when it has reached the adult stage. Immediately after this molt, the female arches the abdomen over its back so that the genital opening, which normally is in a ventral position, is brought to the dorsal side. This posture is held for some time and is held even when the female begins to wander restlessly about the plant after waiting quietly for one or two days.

The adult male does not go through any courting movements. Most males become aware of the proximity of an adult female only when very close to it, and so far as can be determined by observation, remain oblivious to it if the distance separating them is greater than an inch. The male's approach does not seem to depend on sight alone, for the male becomes excited even when the female happens to be located on the opposite surface of the leaf. The act of copulation is simple, the male crawling on to the back of the relatively much larger female, approaching the posterior end, where it takes a position

facing in the same direction as the female, and bending its abdomen around to the ventral side of the latter. The arched or recurved position of the abdomen of the female is given up as soon as its body is touched by the approaching male and during the actual copulation only the tip or posterior end is raised slightly off the supporting surface. The male, while copulating, throws both wings forward so that in the extreme cases the under surfaces of the wings are resting on the back or sides of the female. The time of copulation is variable, lasting from 10 to 40 minutes, the average time for 19 copulations being a fraction less than 22 minutes.

Both the male and the female may undergo copulation repeatedly. One male mated three times in the space of 35 minutes, but the duration of each of these was short. Usually one copulation is not followed immediately by another and a more normal case is that of a male which mated five times in the space of 7 days Females may also copulate repeatedly with the same or different males and one female was observed to mate three times within one hour.

However, in about 4 days after copulation, the fertilized female begins to form its egg sac, which in covering up the genital opening makes further mating impossible. This egg sac is in the form of an irregular mass of waxy threads formed in the vicinity of the genital opening and does not have the definite and beautiful shape seen in various species of Icerya. At the time of its formation, other wax glands distributed over the rest of the body also become active and shorter threads may finally envelop the entire body of the female. If mating does not take place, the female does not form this cottony egg sac so soon, but finally, at the end of 9 or 10 days it also begins to secrete this mass of waxy threads that make copulation impossible. It will be seen, therefore, that the time in which the female can be fertilized is relatively short and indeed it is possible that some type of degeneration sets in before the end of this short period for one female which mated 6 days after molting produced no young. Since the adult male lives only from 2 to 7 days (the adult life of 6 males averaged 5⅓days) it is possible that in these short periods of reproductive effectiveness in the two sexes we have a factor which is in part accountable for the scarcity of the species, especially when it is considered that the colonies are small and scattered, and the flight of the adult male is weak and cumbersome.

EGG-LAYING AND PARTHENOGENESIS.

The fertilized female usually seeks a crevice in the bark of the host plant soon after copulation. The eggs are laid into the cottony mass or egg sac which has been formed previously, the first eggs being extruded in from 4 to 5 days after copulation, (in 8 females this time averaged $4\frac{1}{2}$ days). The female Protortonia does not feed after its last molt, so that nearly all the materials necessary in the growth period of the eggs (the eggs of females in the third instar are still very small) must be present in the body at that time. The number of eggs laid is relatively small, three females under observation producing 16, 50 and 65 eggs, respectively. It is quite possible that these numbers are often exceeded and to some extent there is correlation between the size of the female and the number of its eggs.

The unmated females also lay eggs, although in much smaller numbers, (4 unmated females laid 2, 6, 13 and 20 eggs, respectively). Externally these eggs appear quite like the fertilized eggs, but cytological examination shows that they undergo no development. Of 25 unmated females, not one laid eggs that produced young. It is therefore evident that parthenogenesis does not occur in *Protortonia primitiva*.

THE STAGES FROM EGG TO ADULT.

The following data represent an outline of the study of the brood of a single female. No such careful records were kept of other broods, but enough information was gathered to show that the one here in question is typical.

The brood consisted of 50 first instars or larvæ, of which 49 were raised successfully to the adult stage. The temperature during the period of observation varied from 65° to slightly over 100° F., the average being in the neighborhood of 78.°

Before taking up the various instars of the insect, some reference to conditions in the eggs before hatching is called for. As is well known, in most of the coccids sufficiently studied, development goes on to a variable extent in the body of the mother. In many cases the embryo has already undergone the turning or revolution of its body when the egg is extruded. Such is not the case in *Protortonia primitiva*. There even the earliest cleavage divisions seem to take place after the egg has been laid, and the female plainly is not viviparous. In this

respect, therefore, the conditions resemble those of more primitive insects.

The reproductive system itself is however very much ~~like~~ that of other margarodids. The vagina, a short distance from the genital opening, gives rise to two oviducts. These in turn are continuous with two ovarian tubes to which the ova and their nurse cells are directly attached. Communicating with the vagina is a small pocket which has every appearance of a spermatheca. In the majority of insects, sperms are stored in

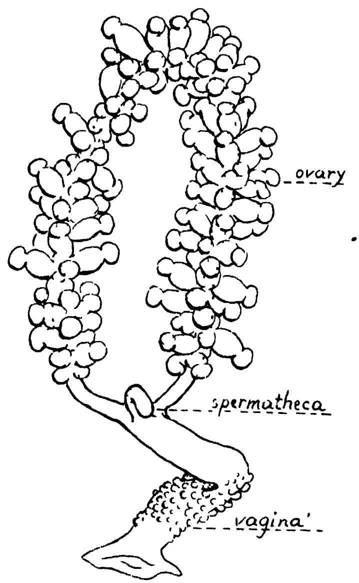


FIG. 1. Reproductive system of a female of *Protortonia primitiva* in the third instar.

the spermatheca and are released in small numbers as the eggs pass the spermathecal opening. But in the present case, the sperms are not retained in this pocket, but travel up the entire length of both ovarian tubes. Therefore it is likely that in most cases the eggs have already been fertilized when they pass the spermathecal opening to be extruded. Accessory glands such as have been described in other groups of the Coccidæ (Berlesi, '09) are not present in Protortonia. It is probable that as in some other margarodids, their function is taken over by the numerous excrescences of glandular tissue covering a large region of the lower part of the reproductive duct. (See text figure).

A feature that may be peculiar to margarodids is to be found in the fact that the two ovarian tubes come together and fuse anteriorly.

The first larvæ hatched from the eggs in 23 days The average duration of the period between egg laying and hatching was 24 days. These first instars were quite active, migrating to the finer branches and the under side of the leaves before attaching themselves. Once attached, this as well as later instars seldom moved before the following molt, although in a very few cases such shifts in position were observed.

The earliest first molt occurred 15 days after the first eggs had hatched, but the average duration of this first instar was 20 days. In molting, the old skin splits in the midline of the anterior half of the dorsal side and this split may extend around the head to the ventral side. The process of molting may last six hours or longer.

The second instars after the molt just mentioned, show a tendency to migrate from the leaves to somewhat stouter branches. The shortest duration of the second instar was 11 days. The average duration of this instar was 14 days The second molt, which terminates the second instar, takes place just like the first molt.

Following this molt, the practiced eye can distinguish males from females by casual examination, the males being longer and flatter. The further history is different for the two sexes, the female undergoing only one more molt before reaching the adult stage, while the male goes through two more molts The first female to go through its last molt did so 17 days after the earliest second molt The average female spent 22 days as a third instar. The males, after their second molt, migrate to a crevice or dark corner where, after one or two days, they secrete a mass of wax threads to form a cocoon, which completely hides them from view. In this cocoon they undergo the two molts mentioned above. The first male emerging as the winged adult, passed through its third and fourth instars in 16 days The average duration of these two instars taken together was 20 days.

Counting the adult stage, the female thus has a total of four instars, while the male has five. Nevertheless, the time interval between the copulation of the parents and the attainment of the adult stage by their offspring was almost identical for the two

sexes. The first male passed through this whole cycle in 74 days, while the first female completed it in 70 days. The average time for male and female respectively was 83 and 85 days.

This must be considered as a rapid development for one of the Margarodidæ. In some cases, two generations could easily be completed in the course of the tropical dry season, and that reproduction is continuous is vouched for by the fact that first as well as all other instars were found all through the early months of the year. Unfortunately no information is available as to reproduction and development during the rainy season, but judging from observations on certain other margarodids, there is probably no cessation of growth during that period. In other words, it seems safe to conclude that two or more generations are completed in the course of a year.

THE SEX RATIO.

Of the 49 individuals reared to the adult stage, 21 were males and 28 were females. That does not indicate an exceptional scarcity of individuals of either sex and such a sex ratio hardly justifies the hypothesis that special processes of reproduction and sex determination obtain in the species.

A conclusion exactly opposite might have been arrived at if no controlled breeding experiment had been made. Previous workers had never seen the male of either of the two known species of Protortonia. Indeed, no adult males were observed in the field in the course of the present investigations, while only three males in the third and fourth instars were seen To some extent such a scarcity of males may be due to their short life period, as well as their small size. Nevertheless, the white cocoons of the males in their third and fourth instars are rather conspicuous and failure to find them must in the main be attributed to the hiding propensities of the males after their second molt. The case illustrates once more the absolute necessity of carefully conducted breeding experiments before any conclusion about reproduction and sex determination in the Coccidæ is made.

REFERENCES CITED.

Berlesi, A. 1909. Gli Insetti, Vol. 1, Soc. ed. lib , Milan.
Hughes-Schrader, Sally. 1925 Cytology of hermaphroditism in Icerya purchasi (Coccidae). Zeit Zellf. mikr. Anat. 2
Morrison, Harold. 1928. A classification of the higher groups and genera of the coccid family Margarodidae. U. S. Dept. Agric., Tech. Bull. 52.

HIGH-ALTITUDE SYRPHIDÆ WITH DESCRIPTIONS OF NEW SPECIES (DIPTERA).

C. L. Fluke, Jr.,
University of Wisconsin.

Pingree Park is a beautiful mountain park which is situated about 50 miles west of Fort Collins, Colo. It has an altitude of 9,000 feet and lies near the base of the Mummy Range, a part of the Continental Divide.

The Park is about two or three miles long and half a mile across at its widest point. A creek meanders through the park and eventually empties into the Cache la Poudre river. On one side of the park slightly elevated above the general surrounding territory is a small pond, known as the "lily pond." Entomophilous flora abounds in this vicinity, offering an unusually favorable and delightful spot for collecting Hymenoptera and Diptera. The banks of the creek also are especially good and it was in the vicinity of the creek in an old pasture which was dotted here and there with small shallow holes, some semi-dry, others with a little water in them, that the species of Helophilus were so abundant.

At the upper end of the Park the country is more rugged with many trees, some swamps, and small beaver ponds. In the more open wooded sections *Arctophila flagrans* and *Syrphus lotus* were quite common. *A. flagrans* was very difficult to capture as the ground was rough and brushy, making it almost impossible to creep upon the specimens.

The following is a complete list of all the species collected in 1924 and 1925. Most of the specimens were collected by the author, although Mr. Beamer added considerable to the list. The list is arranged alphabetically for convenience.

Allograpta obliqua O. S., *Arctophila flagrans* O. S. (10 specimens), *Asemosyrphus mexicanus* Wied. (1 female, Beamer).

Cartosyrphus tristis Lw. (88 females, 2 males).

Chrysotoxum ventricosum Lw. (2 females).

Didea fasciata Macq.

Epistrophe interruptus Mall. (1 male), *E. lincola* Zett., (female), *E. mediaconstrictus* n. sp., *E. pullullus* Snow. *Eristalis anthorphorinus* Fall., *E. brousi* Will., *E. compactus* Walk. (6 specimens), *E. flavipes* Walk., *E. latifrons* Lw., *E. temporalis* Thom., *E. tenax* L., *Eumerus strigatus* Lw. (1 male), *Eupeodes volucris* O. S.

Helophilus borealis Staeg. (1 male), *H. groenlandicus* O. F. (90 specimens), *H. latifrons* Lw., *H. obscurus* Lw.

Lejops perfidiosus Hunter, (1 male).

Melanostoma coerulescens Will., *M. kelloggi* Snow (5 females), *M. obscurum* var. *rostratum* Bigot, *M. stegnum* Say, M. spp., (3 species, one near *concinnum* Sn.), *Mesogramma marginata* Say.

Paragus bicolor F., *P. tibialis* Fall, *Parhelophilus laetus* Lw., *Pipisa quadrimaculata* Panz. (1 female), *Platychirus hyperboreus* Steag., *P. peltatoides* Cur. (3 females), *P. sp.*, *Pyrophaena granditarsis* Forst. (1 female).

Sericomyia militaris Walk., *Sphaerophoria cylindrica* Say, *S. nigratarsi* n. sp., *S. scripta* L., *Sphegina infuscata* Lw. (1 female). *Syritta pipiens* L., *Syrphus amalopis* O. S., *S. lapponicus* Zett., *S. lebanoensis* n sp., *S. lotus* Will., *S. meadii* Jones, *S. montivagus* Snow, *S. opinator* O. S. (Forty-two specimens, including 16 specimens of a variety which has the abdominal bands reaching the side margins, nearly all by their entire width. All are females). *S. perplexus* Osb., *S. pingreensis* n. sp., *S. pyrastri* L., *S. ribesii* L. (1 female), *S. snowi* Wehr., *S. torvus* O. S., *S. wiedemanni*, John. (1 female only).

Xylota notha Will. (2 specimens), *X. pigra* Fabr., *X. sp.*

Epistrophe Walker

Curran, in his recent work published in the Kansas University Science Bulletin (15: 7-216, 1924) has recognized the genus Epistrophe separate from Syrphus principally on the absence of the raised abdominal margins. He also states "if we could eliminate from the face of the earth two or three of these species (referring to intermediate forms), our classification could be greatly simplified . . . ." The following new species of this genus is one of these forms. It can almost be placed in Syrphus as well as in Epistrophe but since he considers *bimaculata* Lovett and *gracilis Coq.* as belonging to the latter, I prefer to place *mediaconstrictus* in that genus. He notes however that *bimaculata* is probably a true Syrphus and while *mediaconstrictus* is intermediate it is more nearly related, I believe, to *gracilis* than to *bimaculata*. For this reason, I am placing the species in Epistrophe. It is significant that all three are known by the females only.

The three species may be separated by the following key.

1. Spots on the second segment reach the side margins ... *bimaculata* Lov.
   Spots on the second segment well separated from the side margins ... 2
2. Antennæ black, cheeks black with black pile, front not pruinose, legs mostly black ... *gracilis* Coq.
   Antennæ dark with yellow areas, cheeks yellowish to brownish and pile light, front pruinose, legs mostly yellow ... *mediaconstrictus* n. sp.

I have not seen either Coquillett's or Lovett's species and I may be mistaken in the assumed close relationship.

Epistrophe mediaconstrictus n. sp.

(Figure 5.)

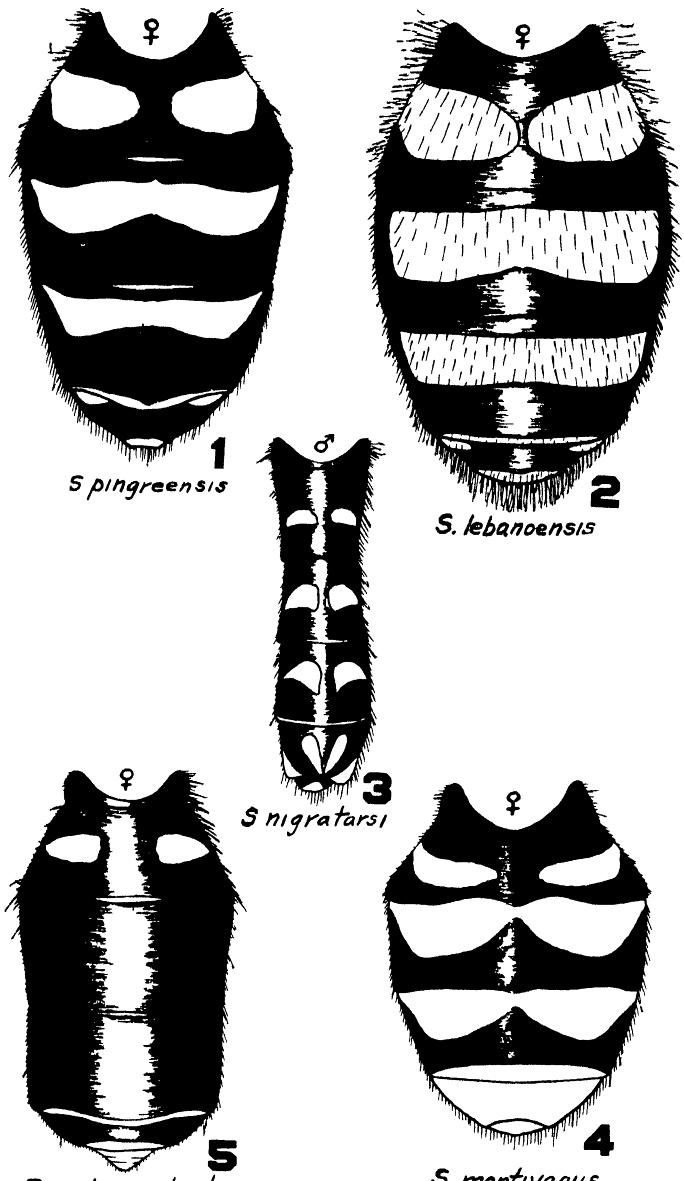
Intermediate between *gracilis* Coq. and *bimaculata* Lov. Face yellow with brown median stripe, front pruinose, scutellum black haired; abdomen constricted at the tip of the 3rd segment and the base of the 4th segment, only the second segment with a pair of spots; caudal end blunt.

Female: Length, 9 mm. Face yellow, with a brown median stripe which fades out before reaching the antennæ, this brownish area follows along the oral opening and over the cheeks, but becomes gradually paler; cheeks not as shining as the face. The pile of the face is black above, but becomes pale at the brown stripe and around the cheeks. Front black with two triangular pruinose spots which continue along eye margins; this area, however, is distinctly separated in the middle by a dark shining line. At the base of the antennæ there is a distinct conspicuous honey-yellow crescent; antennal pits yellow; antennæ brown, first segment almost yellow, underside of others lighter, arista brown, shorter than antennæ. Pile of front black; occiput yellow, white below. Facial tubercle prominent; eyes bare.

Thorax sub-shining bluish bronze, pile all light; scutellum translucent yellow, the corners black; pile all black except the overhanging fringe, which is light.

Abdomen sub-shining black with one pair of yellow spots on second segment. These spots are widely separated and do not reach the lateral margin. They are rounded on their median ends, but acute on their outer ends. Narrow yellow margins on the apices of the 4th and 5th segments, which do not reach the sides on the 4th segment. There is a very faint median or opaque line on the 4th and 5th segments. Pile short and black except on yellow of 2nd segment and on first segment. Venter mostly black, yellow on the margins; the pile long and light on 1st and 2nd sternites, most of the rest is short black, and appressed, except longer on 5th and 6th segments.

The most characteristic feature of the species is the constriction of the abdomen at the base of the 4th segment. The caudal end is nearly squared off with the exception of the very narrow extrusion of the 6th, 7th and 8th segments.



Abdominal patterns of Colorado Syrphidæ

Legs with the basal half of front and middle femora, all but tip of hind femora, and a rather definite ring on hind tibiæ, black; rest of the legs yellowish to brownish.

Pile of front femora mostly yellow at base, blacker and shorter near tip; on middle femora the pile is thicker and blacker; hind femora with short and long pile, mostly black.

Wings hyaline, stigma brownish, 3rd longitudinal vein considerably curved.

Length, 9 mm.

Described from 2 females, holotype in Kansas University Collection, collected at Pingree Park, Colorado, August 16-21, 1925, by R. H. Beamer: paratype same place and date (C. L. Fluke), in collection of the author. The paratype is in every respect similar to the type except that the former is slightly teneral.

Syrphus pingreensis n. sp.

(Figure 1.)

Eyes with very short white pile, faintly so in the male; face with brownish stripe; abdominal bands entire except 1st, sub-interrupted in some cases, only the 1st band on the females reaches the margins. Length 9 to 11.5 mm.

Female: Eyes short white pilous, face yellow with a conspicuous brown to blackish line which does not reach the base of the antennæ, broadens out gradually to the oral opening and passes down the sides of the mouth only a short distance; cheeks black, but separated from the facial line and also separated below the mouth; pile of the face is mostly black but is paler below and along the eye margins, heavier and blacker along the sides of the antennæ; pile on the cheeks and below the oral opening white, continued white along the occiput, but yellow above on the vertex, pile of front all black. Front rather broad, dark shining, with a broad wide Y-shaped marking above the antennæ; this is distinctly separated by a yellow area from the two distinct black dots which are immediately above the base of the antenna; these spots are shining and devoid of pile. Antennæ rather large for a *Syrphus*, about the size of those on *vinelandi*, oval and dark, with light areas beneath each segment, arista rather thickened.

Thorax shining with bronze reflections, pile rather heavy and all tawny, scutellum yellowish with long tawny pile, but with a few black hairs intermixed.

Abdomen broadly oval, black, partly shining, with three yellow undulate moderately broad cross-bands. First band interrupted by a distance less than the width of the band, reaching the side margins by the extreme anterior corners, broader than the two following ones. Band on third segment undulated, distinctly separated from the side

margins and does not touch segment in front; in some specimens subinterrupted, with the rear margin cut in rather deeply. Next band similar, nearer basal margin of segment, yet distinctly separated the entire distance. Posterior margins of segments four and five, and the anterior corners of five yellow. Venter with distinct black bands on sternites two and three, indeterminate on the others.

Legs yellow with the following black areas: coxæ, trochanters, a little more than the basal third of front femora, a little less than a third of the middle femora, all but the tip of the hind femora, and the upper sides of the outer four segments of the hind tarsi. The hind tibiæ and the tip of the hind basitarsi dusky; the front and middle tarsi, except basitarsi brownish. Pile of legs mostly black, rather heavy on outer sides, bent forward at the tips of the hairs.

Wings hyaline; squamæ pale, but the rather long pile on the edges is tawny, disc lightly pilose.

Male: Similar; the specimens before me are slightly smaller than the females The pile of the face darker and a little longer. The black of the cheeks more brownish and connected to the oral margins. The pilosity of the eyes is sparse. Abdomen darker, the first band seldom reaches the side margins, all the sternites with black bands Legs much darker, the black of the femora more extensive and the yellow areas almost brownish. Pile on the sternites long and mostly blackish beyond the second segment.

This species is very closely related to *meadii* Jones, *canadensis Curran*, and *nitens* Zett. If the pile of the eyes is rubbed off or is not carefully looked for the species very much resembles *meadii* Jones. As *nitens* Zett. does not occur in this country we have only to distinguish *pingreensis* from *meadii* Jones, and *canadensis* Curran. Another very good character, at least in all the female specimens I have examined, is the color of the long hairs on the 3rd sternite. In *pingreensis* this is mostly black while in *meadii* it is usually sparce and whitish. In the latter the pile of the face is less extensively black. In *canadensis* the spots on the 2nd segment are separated from the side margins (female). If the eyes are pilose there should be no question as to the determination of the species when these are concerned.

I have at hand another female sent to me by Mr. Curran which was collected at Victoria, B. C., May 16, 1916, by R. C. Treherne. This specimen, I believe, is the same although the pile on the eyes is definitely evident only on the lower corner of the left eye; apparently the rest has been rubbed off. It is also a little lighter in color especially the hind legs, but I believe the specimen is slightly teneral.

Holotype female collected by the author at Pingree Park, Colorado, August 16-21, 1925, in the collection of the author. Allotype male same data.

Paratypes as follows: 3 males and 2 females, same data as the type in the collection of the author; a male collected May 31, 1926, at Seton Lake, Lillooet, B. C., by J. McDunnough and a female collected, May 16, 1916, at Victoria, B. C., by R. C. Treherne in the Canadian Nat. Collection; a female Pingree Park, August 16-21, 1925, (Beamer) in the collection of the University of Kansas.

Syrphus lebanoensis n sp

(Figure 2.)

Eyes bare. Face entirely yellow, abdomen with broad yellow crossbands which do not reach the side margins except the pair of spots on the second segment. Front of male yellow.

Male: Length, 10 11 mm. Eyes glabrous Face and front yellow In one specimen there is a narrow brownish arc above the antennæ The oral edges are very lightly brownish, but the rather prominent rounded tubercle is entirely yellow. The cheeks are black, but are separated below the mouth by a distinct and a broad yellow area The pile is mostly whitish to yellowish, moderately heavy, but is black on the front along the sides of the antennæ, and on an area on each side of the tubercle; in one specimen the facial pile is mostly black. The facial line is glabrous. Pile on the cheeks white, on the occiput, white below, yellow above. Vertex black with black pile Antennæ brownish, yellowish below, third joint oval and rather large; arista brown, not much longer than third segment.

Thorax dark blue shining with light brownish kinky pile. Scutellum yellowish, obscurely blackish at the basal corners, pile mostly black and also kinky.

First segment of the abdomen shining bluish; second segment with a pair of large yellow spots which occupy the center of the segment and are a little wider than half the width of the segment, separated by about half their width, and reach the side margins by their corners only; third segment with a broad, non-interrupted yellow band which is well separated from the anterior margin of the segment and from the side margins, the band is straight on the anterior edge and broadly although not deeply cut in on the posterior margin, about as wide as one-half the width of the segment; fourth segment similar except the band is smaller, and cut in posteriorly a trifle more; posterior margins of fourth and fifth segments and the anterior corners of the fifth also yellow. The black areas of the abdomen are sub-shining, although more shining on the posterior margins of the segments.

Second, third, and fourth sternites with distinct black bars, first with a black spot; the long pile on these sternites rather abundant, yellowish and kinky, except on the fourth, where it is sparse and mostly black. The short appressed hairs on the 3rd and 4th sternites are quite numerous and black.

Legs yellowish or reddish except the coxæ, trochanters, and the basal one-third to one-half of the front femora and the basal two-thirds to three-fourths of the hind femora. At the extreme bases of the hind femora there is a yellowish ring which is more obscure on the others. The pile is mostly yellowish except on the hind legs, where it is nearly all black.

Wings hyaline, stigma light brownish. The squamæ pale with rather long brownish pile on the edges, pilose on the disc; the plumule with whitish hair.

Female: Quite similar; the pile on the face is more yellowish and there are very few or no long hairs on the third and fourth sternites. Front is yellow just above the antennæ to the indefinite black line of the ocellar areas. In the single female from Colorado there is a rather definite Y-shaped marking on the front, the two arms of the Y reaching to the bases of the antennæ. Legs all yellow except the coxæ and trochanters.

Type female Seton Lake, Lillooet, B. C., June 27, 1926 (J. McDunnough) in Canadian National Collection. Allotype male Keremeos, B. C., June 20, 1923 (C. B. Garrett) in the collection of the author.

Paratypes as follows: one female (Seton Lake, Lillooet, B. C., June 27, 1926. J. McDunnough); two females Keremeos, B. C., June 27 and 30, 1923 (C. B. Garrett); one female Anderson Lake, D'Arcy, B. C., June 17 (J. McDunnough), one male Keremeos, B. C., June 30, 1923 (C. B. Garrett) in the Canadian National Collection; also one male Keremeos, B. C., June 20, 1923 (Garrett); one female Pingree Park, Colorado, August 21, 1924 (Fluke) and one female Pingree Park, Colorado, August 16-21, 1925 (Fluke) in the collection of the author.

This species, superficially, resembles *wiedemanni*, but the face is entirely yellow; from *opinator* it is easily separated on the size and shape of the abdominal bands, the black cheeks and the absence of hairs on the disc of the squamæ.

Syrphus meadii Jones.

Male: Frontal triangle yellow with two black dots above the antennæ, pile rather conspicuous and black; extending down the sides, next to the eye margins, to a point just opposite to the upper black tip of the facial line. Face pure yellow with a distinct black shining stripe

over the knob and joined to the black oral margin. Cheeks also black and connected to the facial stripe with little yellow between eyes or mouth edge; but distinctly interrupted below the mouth edge; pile of lower part of face and cheeks all pale. Vertex black with black pile, yellow behind and pale above and below on the occiput. Antennæ dark, but considerably lighter on the underside; in some specimens the third segment is almost blackish brown.

Thorax shining greenish to bluish, pile all pale whitish to tawny; scutellum yellow with extreme basal corners dark, pile intermixed with yellow and black, mostly dark on disk.

Abdomen mostly shining black with yellow undulating crossbands, considerably separated from the side margins; the yellow does not even reach the rolled edges on segments three and four. The spots on the second segment are rounded and separated by nearly their width, pile mostly pale on the sides. Bands on third and fourth segments beautifully undulated and greatly emarginated in the middle, although none of them are completely separated; only occasionally is there an anterior projection in the middle. Band on fourth segment separated from rear margin of segment three. Rear margins of the fourth and fifth segments yellow; there is also a pair of spots on the anterior corners of segment five. The pile is black along the side margins of these segments. Venter with distinct black rectangular spots.

Legs yellow with the following black areas; the basal third of the anterior femora, the basal two-thirds of the rear femora, and the hind tarsi above. The hind tibia and fore tarsi above are fuscous.

Wings hyaline with brownish stigmal spot.

Length 10 to 12 mm.

The female is very similar except the yellow of the legs and face is more extensive, there being no connection of the facial line with the black of the cheeks. Described from specimens collected at Pingree Park and compared with the type by C. R. Jones, who determined them as conspecific with his species.

Syrphus montivagus Snow

(Figure 4.)

Kans. Univ. Quart. 3: 236, 1893.

Characterized by the broad dark red crossbands, somewhat narrower in the female. These bands have no indication of yellow.

Female: Length, 9 to 10 mm. Face yellow, with a rather prominent tubercle which is brownish to blackish. Cheeks shining black, connected to the rather broad black margin which is also black below the mouth opening. Pile of face sparse, short and yellowish, also yellowish but longer on the cheeks, rather short and whitish on the

occiput below, tawny above. Front obscurely marked, vertex black and extended in a narrow median irregular line toward the antennæ, but widely separated from them by a yellow area which has two black dots just above the bases of the antennæ. In one specimen these spots are almost obscure. Pile of front not very long but black, the black hairs also found along the sides of the antennæ. Antennæ brownish, lighter on the under sides, 3rd segment rather large and oval, arista thick, shorter than the length of the antennæ. Eyes almost bare; there are a very few extremely short white hairs on the eyes; these show up in good light under a high power binocular.

Thorax dark sub-shining, scutellum dark opalescent, black at the basal corners. Pile rather heavy and tawny, with a few black hairs on the scutellum. Pile of pleuræ rather sparse, tawny. Squamæ pale, disc pilose, hairs on edges light brown.

Abdomen broadly oval with dark blood-red crossbands. Band on 2nd segment interrupted by about the width of the band, reaching the side margins obscurely by the extreme anterior corners only. Next crossband broad, almost touching the preceding segment, sub-interrupted in the middle by a deep posterior notch, reaching obscurely the anterior side margins. Band on the 4th segment similar except it touches the posterior margin of segment three its entire length excepting a small area on the anterior corners only. This band is broadly notched posteriorly and reaches the side margins anteriorly. Posterior margin of segment four and all of the following segments red. Venter mostly red with black areas on the anterior sternites. The ventral part of the side margins is largely black. Pile rather long and light in color on the 2nd sternite, sparse and whitish on 3rd. The short black appressed tiny bristles numerous.

Legs reddish with the following definite black areas: coxæ, trochanters, basal third of front and middle femora, and basal two-thirds of hind femora. The upper sides of the outer tarsal segments brownish.

Wings hyaline with the stigma brownish, continued to base of wing.

Three female specimens, two taken at Pingree Park, Colo., August 16-21 1925, by the author, and the other, same date and locality collected by Beamer, in collection of University of Kansas.

This beautiful species is easily recognized by the blood-red color of the abdominal bands.

For sometime I considered these females as a distinct species but a careful comparison with two male specimens of the original lot of forty males collected by Snow seem to show that these are the females of Snow's species. It is interesting to note that the males were taken at Estes Park in August 1892, and to my knowledge not heard of since. The females were

caught at Pingree Park, only about a dozen miles away from Estes Park. I searched diligently at the time for males but found none. The females were taken near the lodge on dandelion blossoms.

Sphaerophoria nigratarsi n. sp.

(Figure 3.)

A very slender species with 4 pairs of yellow spots, black oral margins (male) and brownish or black tarsi.

Male: Length, 7.5 mm. Face yellow, but with the tubercle brownish; this color is continued down around the oral margins to the cheeks, which are black. The pile is all pale, even on the front, which is pure yellow in ground color. Vertex black with black pile. Antennae brownish to yellowish, arista brown.

Thorax dull, the yellow side margins distinct to the suture, but very indistinct the rest of the way. Scutellum yellow, black at the basal corners. Pile of thorax pale, a few black hairs intermixed on the scutellum.

Abdomen black with 4 pairs of yellow spots and with yellow rolled side margins. On the fourth segment there is an indication of a connection of the yellow of the sides with the spots on that segment. All the spots are rounded and broadest on their inner margins; the outer margins ending in points, all separated from the side margins except as noted on segment four. The shape of these spots are like apostrophes except those on the 5th segment, where they are exclamation points with the points converging apically until they touch at their tips. The posterior margin of the fourth segment narrowly, that of the fifth broadly yellow. The spots are situated a little anterior of the middle of each segment. The two black spots on the dorsum of the 6th segment rather prominent. Genitalic segments swollen and brownish, with black on the inner margins (the 2 margins touching the sides of the venter of the fifth segment). The pile on the styles tawny. Venter unicolorous.

The legs yellow, with the coxae, trochanters and basal one-third or one-half of the femora black. All the tarsi black, especially from above. Most of the pile is black except on the front tibia and the undersides of the tarsi. In one specimen the legs are more extensively dark, the hind femora nearly all dusky or black.

Female: The face is more yellow, only the cheeks black; antennae yellowish, the front marked as in other species of this genus; the legs are paler, all yellow, including the coxae and trochanters, except the tarsi, which are light brownish on the front and middle pair, but darker on the hind pair. With the exception of the first pair, which are very narrow, the abdominal spots are narrowly connected with the yellow side margins. They are all narrow bars, not at all like in the male.

In another female (var.) the abdominal bands are broader and broadly connected with the sides even the first pair. They are all interrupted by a little less than the width of the bands. In this female specimen the upper mouth edge is very narrowly black.

This species resembles *S. interrupta* Jones. It is readily separated from this species by the position and shape of the narrow abdominal bands and the color of the legs.

Type male Pingree Park, Colorado, August 23, 1924, collected by the author and in his collection.

Paratypes: One male Pingree Park, Colorado, August 23, 1924, (Fluke) in the Canadian National Collection. One male and one female August 21-23, 1924; one female August 16-21, 1925, same place; in the collection of the author; two females collected by R. H. Beamer at Pingree Park 1925, in the collection of the University of Kansas. These two specimens are similar to the female variety noted above.

I believe these three last named females belong to *nigratarsi* although they vary considerably from the one female collected in 1924. My reasons for retaining the single female as typical of the species are based principally on my collecting notes. The single female and the three males were all collected on a little knoll near the "lily pond." On August 21, 1924, one male and the female were taken together at the same sweep of the net. Two days later at the same spot the other two males were caught. A year later collecting in this same region revealed the varietal female. Beamer also caught his specimens in 1925.

A SIGNIFICANT FEATURE OF BIOTIC POTENTIAL AS RELATED TO INSECT CONTROL.

C. R. CUTRIGHT,
Agricultural Experiment Station, Wooster, Ohio.

In reviewing the literature dealing with biotic potential it is found that there are two conceptions as to the importance of this general idea. Brues, considering it in the light of ultimate insect abundance, concludes that it is relatively unimportant and that environmental resistance plays the great part in the fluctuation and stabilization of insect populations. Many illustrations can be given showing that this view is fundamentally correct when time is not considered as a factor. Chapman and his students consider that time is of definite importance and therefore give to biotic potential a place of much greater value.

Entomologists whose problems are in the economic field find themselves obliged to select one or the other of these conceptions so that they may plan their research with a definite viewpoint in mind. In studying this situation as it applied to his particular problems the writer used the following procedure as an aid in arriving at a decision. A rectangular diagram was constructed to represent in its entirety the possible ranges of insect abundance. On this were placed the different insects concerned in the problems and as more or less was known about their potentialities and their reactions to environmental resistance and different control measures some conclusions were reached as to the preferred viewpoint. The diagram (Fig. 1) may be explained as follows: On the ordinate is plotted the entire possible range of environmental resistance as it will affect absolute numbers of insects, with all factors unoperative at the bottom of the scale and all fully functioning at the top. On the abscissa is placed the range of biotic potential graded as indicated on the diagram. The position of the potential of any insect as determined by Chapman's formula may now be placed definitely. For purposes of illustration three insects and one mite having a wide variation in their biotic potentials are now located on the diagram as shown by the broken lines 1-1., 2-2., etc. At the left is placed the round-headed apple tree

borer, an insect with a very low reproductive capacity. In Ohio it requires from two to three years to complete a single generation and each female deposits only about 25 eggs. The sex ratio in this species is approximately equal. Next is placed the codling moth according to its potential as manifest in Northern Ohio. Here this insect has one and a half generations per year with each female depositing about seventy-five eggs. The sex ratio is slightly in favor of the females. The European red mite has a much higher potential, each female will produce 20-30 eggs and there may be six generations per year with the sex ratio about equal. The green apple aphis is

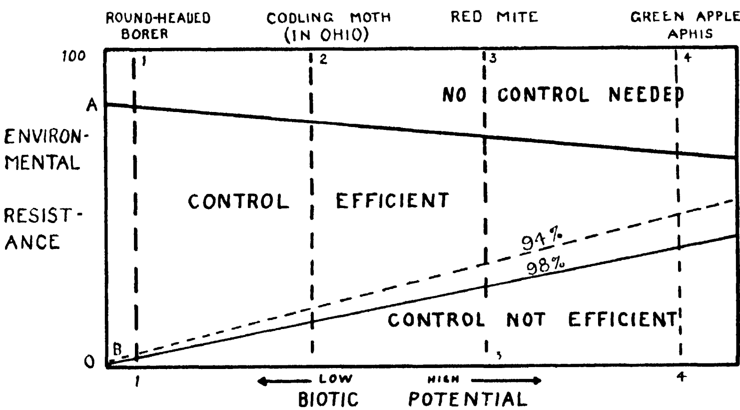


FIG. 1. Commercial injury as affected by biotic potential and environment resistance.

an example of an insect with a very high biotic potential. It will reproduce at an average rate of about thirty-five per individual, the sex ratio is one, and there may be twelve to fifteen generations per year.

The diagram may now be considered in its entirety. As the environmental resistance drops the first group of insects that will be noticed as injurious are those with low reproductive capacities. Insects with high biotic potentials will not appear doing commercial damage until the resistance drops still further since high biotic potential is always offset by greater environmental resistance. Therefore a line A A drawn diagonally across the rectangle is necessary to divide it into two sections, one of which represents insects in numbers where no injury is evident, or no control needed, and the other in which

commercial injury is being done. (Fig. 1) is drawn to illustrate the ecological relation existing between environmental resistance and biotic potentials of different degrees and is not concerned with control measures that may be used against the different species. In order to show what takes place when control measures are brought upon the scene (Fig. 2) has been developed from (Fig. 1). Here the lines B-B₁ and B-B₂ indicate what takes place when control measures of different degrees of efficiency are applied. When a control 94 to 98 percent effective is used against an insect with a biotic potential as low as that of the round-headed apple tree borer, the insect will undoubtedly

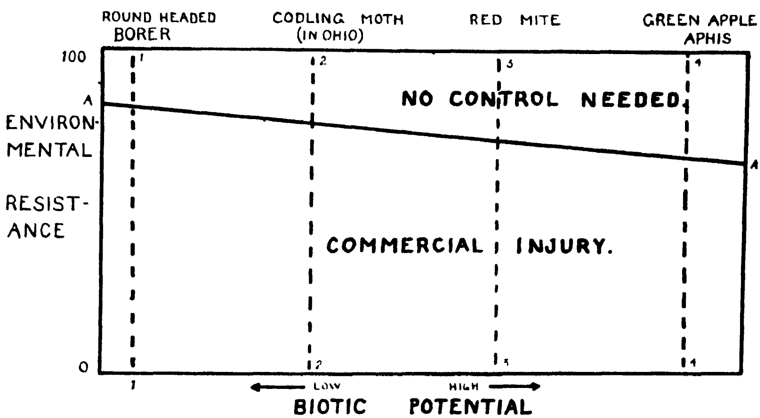


FIG. 2. Efficient insect control as affected by boitic potential and environment resistance.

be controlled for that season and usually for from two to five years in addition, unless factors such as migration intervene. With the codling moth in northern Ohio a control of 94 to 98 percent will practically always hold the insect in check for the year but for no longer. In the case of the European red mite we have many instances in which a 98 percent control at the beginning of the season was not sufficient to keep the mite population low for the remainder of the year. In these seasons environmental resistance was low and during such periods the high biotic potential enabled the mite to rapidly increase its numbers. What is true for the European red mite is true in even greater degree for the green apple aphis where only a few weeks of low environmental resistance enable the aphids to

increase to outbreak proportions. The lines B-B_1 and B-B_2 will therefore be placed diagonally across the rectangle with B-B_2 inclining more toward the horizontal. We now have in the rectangle three areas, the first of which we have already discussed under "no control needed." The middle space shows the area in which effective control of the insect may be obtained. According to the preceding discussion this area is in the shape of a cone and the decreasing chances of successful control are clearly shown as we proceed toward the higher biotic potentials. The third area is that in which no control measure will be effective. The chances that a control of from 94 to 98 percent effectiveness will fail where the insect concerned has a low potential are practically negligible, while in the case of those with high potentials such a control amounts to little if the environmental resistance is low.

Certain conclusions that may very well be termed practicable can be drawn from the above study; in the first place extension entomologists in giving advice regarding insect control must always remember that if the insect has a high potential that the chances of recurrent infestation are many and that the farmer or grower should be informed of this fact. Second, if a research entomologist has determined that the insect with which he is dealing possesses a low potential, then he may well concentrate on the perfecting of one good control measure for such a measure will be successful. If the insect possesses a high potential then all possible lines of control must be investigated and developed if a sure method of control is to be found. Third, in so far as economic work is concerned the entomologist has no choice but to accept the definition and value assigned to biotic potential by Chapman

BIBLIOGRAPHY

Chapman, R. N. Animal Ecology with Special Reference to Insects. Burgess-Brooke, Inc., Minneapolis, Minn., 1925.

Graham, S. A. Principles of Forest Entomology. MaGraw-Hill Book Co., New York City, 1929.

Brues, C. T. Choice of Food and Numerical Abundance among Insects. Jr. Ec. Ent. vol. 16, p. 46 1925.

THE TRACHEAL SYSTEM OF THE LARVA OF LISSORHOPTRUS SIMPLEX[1]

Dwight Isely and H. H Schwardt,
University of Arkansas

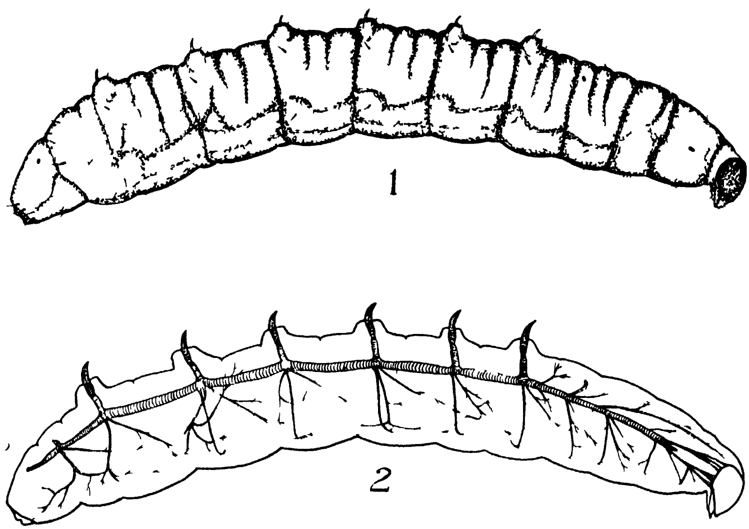
The immature stages of the rice water weevil, *Lissorhoptrus simplex* (Say)†, are passed entirely below the water, either in or among the roots of rice and other aquatic grasses. The eggs are deposited in the roots, and the female beetles will not deposit eggs unless these roots are submerged. The small larvæ feed first within the roots in which they hatch, and as they grow larger they live in the mud around the roots upon which they feed. Pupation takes place in a water-tight cocoon attached to a rootlet. The entire time required for passing the immature stages in the insectary, from deposition of the egg to transformation to the adult stage, may be as brief as 32 days and as long as 77 days. The remedial measure recommended is temporary drainage of the rice fields, allowing them to dry until the ground cracks. This is very effective in destroying the larvæ.

Although the entire larval period is normally passed under water, the larvæ cannot obtain an adequate supply of oxygen directly from the water. When placed in water free from roots, the larvæ drown, as a rule, within 24 hours. Individuals have shown signs of life 60 hours after submergence, but they were no longer normally active. The results are the same if the larvæ are placed in clear water or if roots of plants which were not previously flooded were placed in water with them. On the other hand, larvæ placed in moistened cells from which there was almost no evaporation and supplied with pieces of roots, fed and developed for a time apparently in a normal manner. Larvæ fed in this manner apparently became full grown, but always died without formation of the pupal cell. It is obvious that although larvæ are normally submerged throughout their entire lives, they can secure an adequate supply of oxygen directly from the air. On the other hand,

*Research Paper No. 165, Journal Series, University of Arkansas
†Order Coleoptera, Family Curculionidæ

while it is possible that they may derive some oxygen from water directly, it seems that this is not sufficient to maintain life for a long period.

The larva of the rice water weevil is whitish, elongate, sub-cylindrical, and about 8 mm in length. Its most striking characteristic is the presence of paired dorsal hooks occurring on each of the abdominal segments from the second to the seventh inclusive. These hooks are curved forward and arise from ridges on the last fold of each segment. At first glance,



Lissorrhoptrus simplex (Sav).

1 Larva, lateral aspect

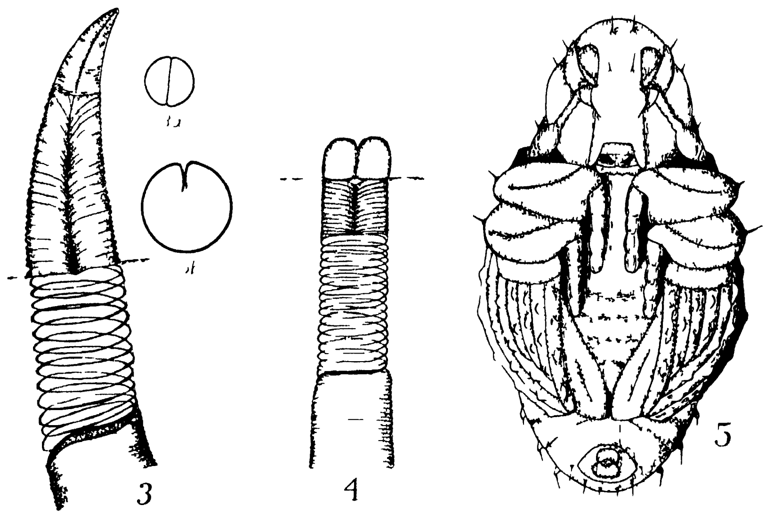
2 Tracheal system of larva, lateral aspect (tracheal system somewhat diagrammatic), s, spiracles

it might appear that the function of these hooks is locomotor, and doubtless they are used by the larva in forcing its way through the mud around the mat of roots.

A more important function, however, is probably respiratory. These hooks are grooved on the mesal surface and are connected by large trachæ with the main longitudinal tracheal trunks Apparently these hooks are modified spiracles. No other spiracles occur on any of the segments which bear the hooks Pairs of spiracles do occur, however, on the second thoracic and first and ninth abdominal segments. The third pair of spiracles which reach the surface on the ninth segment

are openings of a pair of tracheæ which arise from the main tracheal trunks in the eighth abdominal segment. All of the tracheal branches leading to the typical spiracles are smaller and apparently less important than those leading to the dorsal hooks. The large tracheal branches as well as the tracheal trunks can be observed easily in living larvæ under a binocular microscope.

The dorsal hooks are partially retractile The apical part is heavily chitinized, and its surface is marked by very fine



3 Dorsal hook greatly enlarged, showing connection with trachea
3a Cross section of apical portion of hook
3b Cross section of basal portion of hook (somewhat diagrammatic)
4 Last abdominal spiracle of larva showing connection with trachea (somewhat diagrammatic)
5 Pupa

transverse striæ visible only under high magnification The apical portion, when viewed in cross section, is diametrically divided from its tip to its base, by a highly chitinized line, or partition. This partition is apparently formed by the fusion of two infolded walls, suggesting the fusion of opposite sides of the spiracle When the apical portion of the hook is viewed laterally this partition is plainly visible for its entire length on either side.

The basal part of the hook is distinctly tubular It is formed of heavy rings, infolded on the median side in such a

manner as to form a deep groove, apparently reaching to the central tube. The grooves on each pair face each other. The basal part of the hook may be drawn below the integument. The basal part of the hook is attached to the occluding chamber which in turn is attached to the trachea. The occluding chamber is separated from the hook and also from the trachea by heavily chitinized rings.

The similarity between the hook and the spiracle is obvious. Like the apex of the hook, the chitin of the spiracle is marked by very fine transverse striæ. The basal part of the hook is analogous to the anterior chamber of the spiracle below the integument. The occluding chamber and the tracheal attachments are the same.

The writers are of the opinion that the rice water weevil larva obtains its oxygen when below water from the roots of the rice plants. The roots of rice plants which have been submerged for a few days have an inflated appearance and have large cells filled with air. The small weevil larvæ which live within the roots doubtless derive their supply of air from these cells. We have not been able to show that the larger larvæ outside of the roots obtain their air from the same source. However, since the larvæ cannot secure enough oxygen from the surrounding water it seems logical to assume that these hooks are modified spiracles fitted for piercing the air cells in the roots among which they live and obtaining air from them.

In this discussion we are concerned chiefly with the larva. It may be worth while to note, however, that the spiracles of the pupa do not appear to be unusual. It is obvious that the pupæ do not obtain their oxygen directly from water. The pupal stage is passed in a water-tight, inflated cocoon. These cocoons are oval in shape and mud-covered and are always found attached to a rice root.

BEE-FAUNA AND VEGETATION OF THE MIAMI REGION OF FLORIDA.

S. Graenicher,
South Miami, Florida.

In the central part of Florida the Tropical Life Zone reaches its northern limits in the region southwest of the northern end of Lake Okeechobee. Along the coasts it extends farther north, especially so on the East Coast, where it forms a narrow strip along the Indian River. Miami, the county seat of Dade County, is situated about half way between the northern and the southern limits (Key West). Based on a study of the vertebrate fauna, as also on the evidence offered by E. A. Schwarz (insects), W. H. Dall (mollusks) and C. S. Sargent (trees), C. Hart Merriam (**12,** 406) reached the conclusion that "there exists in Florida a well-marked sub-tropical fauna and flora consisting in the main (except in the case of terrestrial mammals and reptiles which could not reach it) of genera, and largely of species, identical with those of Cuba." Referring to the native vegetation of the "Miami Limestone Region," Dr. J. K. Small (**22,** III) states that "it is essentially of a tropical character, with strong relationships to the flora of Cuba and the Bahamas."

The bee-fauna of the Miami region is surprisingly poor, both in number of species and of individuals. During a residence of over 12 years in the vicinity of Miami, the writer has given much of his spare time to a study of the bees of the region, and some of the biological aspects connected therewith. Persistent collecting will undoubtedly reveal the occurrence of some additional species; the writer, however, considers the list given herein as fairly complete.

The latter part of the paper will be taken up with a discussion of the types of vegetation found within the region.

List of Bees.*

Colletes Latreille.

C. latitarsis Robt. This bee collects its pollen exclusively from the ground cherry (species of *Physalis*). The most common ground cherry of our region is *P. viscosa*,† on the flowers of which I have taken the bee on numerous occasions in the pinewoods at Miami and South Miami, and on the sand dunes at Miami Beach and on Biscayne Key (across the Bay southeast of Miami). It flies throughout the year.

Robertson (**16**, 317) has found it at Inverness, Fla., on *Physalis arenicola*.

I have examined the male genitalia in order to leave no doubt as to the identity of the species. A comparison of specimens from Miami with some from Milwaukee, Wis., shows a marked difference in the puncturation of the abdominal segments, especially of the basal one. In the Miami material the punctures are finer and farther apart. Such differences in sculpture in species ranging over a wide territory are occasionally met with.

C. distinctus Cress. The male genitalia were examined and found to agree with Swenk's illustration (**27**, Pl. II, 8, 8a). A male and a female were taken April 21 and May 1, on a window.

Reported by Robertson from Inverness, Fla. (**16**, 279).

? **C. mandibularis** Smith. ♂. Described from Georgia The males in my collection agree well with Smith's description (**25**, 5), as also with the information furnished by Cockerell, who examined the type in the British Museum (**1**, 276), but they are larger (about 7.5 mm.) Both males and females are decidedly smaller than those of *C. howardii* Swenk (**28**, 5), and are entirely different. Taken at South Miami, Miami and Hollywood (16 miles north of Miami) at the flowers of *Pterocaulon undatum*, *Flaveria linearis* and *Petalostemon carneus*. The females were collecting pollen from *Flaveria* (*Compositæ*) and *Petalostemon* (*Leguminosæ*). Time of flight from about March 30 to June 11.

*It is with feelings of pleasure and appreciation that the writer mentions the names of the following who have been helpful to him in various ways: Prof. T. D. A. Cockerell, University of Colorado, Boulder, Colo.; Mr. J. C Crawford, North Carolina Dept. of Agriculture, Raleigh, N. C.; Prof. T. B. Mitchell, North Carolina State College, Raleigh, N. C.; Prof. Chas. Robertson, Carlinville, Ill.; Mr. S. A. Rohwer and Miss Grace Sandhouse, Bureau of Entomology, Washington, D. C.; Mr. H. F. Schwarz, Am. Museum of Natural History, New York City; Prof. P. H. Timberlake, Citrus Experiment Station, Riverside, Calif. I have also been ably assisted in my collecting activities by my daughter, my cheerful companion and chauffeur on many a trip.

†Nomenclature according to J. K. Small, Flora of Miami, Flora of the Southeastern United States, etc. I have, however, preferred to retain such well-established family names as *Compositæ* (*Carduaceæ* according to Small), *Leguminosæ* (*Fabaceæ* Small), etc.

Hylaeus Fabricius (**Prosopis** Fabricius)

H. schwarzii Ckll. (**Prosopis schwarzii** Ckll.) ♀ Ent Mag. **32,** 218 (1896); ♂, Entomologist 1898, p. 216.

The type material is from Dade Co., Fla. I sent a ♂ and a ♀ to Prof. Cockerell, who kindly compared my specimens with a ♂ and a ♀ collected in Florida several years ago by Prof. Chas. Robertson. He writes as follows: "Your ♀ agrees very closely with the Robertson ♀, differing by the strictly narrower lateral face marks, and duller, rather more closely punctured mesothorax and scutellum, and also the rougher area of metathorax, without fine striæ on the basal parts. The ♂ from Robertson differs more conspicuously with the lighter area on clypeus deeply incised above." He further states, "your ♂ has black tubercles; in the Robertson one they are light as in the ♀."

The ♀♀ in my collection differ considerably in the breadth of the lateral face marks. All of the ♂♂ have the clypeal face marks incised above. These marks vary in extent, taking in from one-half to nearly the whole of the clypeus. The black linear space separating the lateral face marks from the clypeus varies in width, and in each of two specimens this black linear space is much narrower on one side than on the other. All of this shows *H. schwarzii* to be a very variable species. Metz, in his "Revision of the genus Prosopis of N. Am.," (**13**, 151) places it among the uncertain species, and says that it is evidently of the *Modestus division*, but cannot be located with certainty until the male genitalia are examined. Such an examination by the writer shows the following characters:

Genital armature: Like that of *modestus* (Metz, Pl II, Fig. 12), but sagitta longer and cardo divided in the middle.

Seventh ventral plate: Wing like *fossata* (Pl. V, Fig. 71), but proximal arm more like *episcopalis* (Pl V, Fig. 74).

Eighth ventral plate: Resembles that of *fossata*, (Pl. III, Fig 28).

H. schwarzii is without question a member of the *Modestus division* (with characters in common with *modestus*, *fossata* and *episcopalis*) which has extended its range into the sub-tropics of Florida. It has been taken throughout the cooler season from October 1 to May 2. An account of its relations to flowers, etc., will be found in the part of this paper dealing with the "Marl Prairie" type of vegetation.

Hylaeus sp. Two females (one of which is minus the head) were captured December 22 and January 4, in a small tract of pinewoods in the northwestern section of Miami. Length about 4 mm Black, with much red on the first two abdominal segments. Lateral face marks, clypeus, pronotum, tubercles and tegulæ yellow. Legs testaceous with bases of tibiæ and femora blackish. Wings hyaline with dark nervures and stigma, the latter unusually large and conspicuous.

This species reminds one of *nelumbonis* Robt. and *flammipes* Robt. (from Citrus Co., Fla.) but it is much smaller. It is probably new, but its status can hardly be established before additional material (especially the ♂) has been obtained.

Halictus Latreille.

A paper by the writer on the bees of this genus appeared in Psyche **34**, 203-208 (1927).

H. (**Chloralictus**) **marinus** Crawf I am indebted to Mr. J. C. Crawford for having compared one of my females with a female in his collection from Virginia Beach, Va. He found the face narrower in the Miami specimen, as also some differences in sculpture on various parts of the thorax. Later on I sent some specimens of both sexes to the U. S. National Museum, where Miss G. Sandhouse kindly made comparisons. She, too, saw some differences in sculpture in the females, but according to her letter, the males from Miami agree very well with those in the National Museum (determined by Crawford) in *genital*, as well as in *external*, characters. She is, therefore, of the opinion that the Miami material belongs to *marinus*. In my former paper (Psyche **34**, 203) I expressed the view that the species would probably be found in the dune regions along the shores of the Atlantic between Miami and the type locality in Virginia.

H. (**Chloralictus**) **lepidii** Graen. Psyche **34,** 204 Type (♀) and allotype (♂) deposited in the U. S. National Museum

Its period of flight covers the entire year. For flowers visited, localities, etc., see Psyche **34**, 204.

H. (**Chloralictus**) **nymphalis** Smith Flies throughout the year Additional information in Psyche **34**, 205.

H. (**Chloralictus**) **longiceps** Robt. This species, too, may be found in any month of the year. To the localities given in Psyche **34**, 206, may be added Homestead (south of Miami) and West Palm Beach (north of Miami).

H. (**Chloralictus**) **halophilus** Graen. (Not **halophitus,** as it appeared in Psyche **34**, 206.) Type (♀) and allotype (♂) deposited in the U. S. National Museum.

Since describing this species I have come across it in two additional localities, both north of the type locality at Cutler. According to information gathered in 1927, it flies from about the middle of April to the end of October. Males were captured from April 20 to August 25, and females from May 20 to October 23. Its relations to the halophytic vegetation along the shores of Bay Biscayne will be considered further on, under the "Coast Prairie" type of vegetation.

H. (**Chloralictus**) **rhododactylus** D. T. Found once only, Homestead, July 19, 1916, ♀.

H. (**Odontalictus**) **ligatus** Say. Exceedingly common throughout the year. Flowers visited: *Lepidium virginicum, Warea Carteri, Pycnothymus rigidus, Helianthus debilis, Pterocaulon undatum, Bidens leucantha, Melanthera parvifolia.*

H. (**Evylaeus**) **nelumbonis** Robt. One ♂, South Miami, February 26, 1927, on the flowers of *Sagittaria lancifolia*. Reported by Robertson from Orlando and Inverness, Fla., (**16**, 279). Visits mostly the flowers of aquatic plants.

The writer has come across three additional species of *Halictus* (subgenus *Chloralictus*), which have not been identified on account of the lack of suitable material, especially males.

Augochlora Smith.

Miss Grace Sandhouse, of the Bureau of Entomology, U. S. Department of Agriculture, has been carrying on a revision of the Halictine bees of North America, and is at present studying the genus *Augochlora*. I have welcomed this opportunity to send her my material for identification, and herewith express my thanks for the information received. There were 170 specimens in the lot, and the 4 species recognized by her were represented as follows: *pura* 66 specimens, *festiva* 56, *cuprea* 37, and *fulgida* 11. The types of *festiva*, *cuprea* and *fulgida*, as well as of the other species described by Frederick Smith (**25**) are in the British Museum. Miss Sandhouse states that she will have to have some of the material from this country compared with the Smith types, before feeling more certain about the identity of the species, and that the names furnished me are according to her present interpretation of the species.

The records on hand indicate that all of the species are in flight throughout the year.

A. pura Say. This widely distributed species is of common occurrence, and has been found south of Miami as far as the Royal Palm State Park. Flowers visited: *Warea Carteri*, *Oxypolis filiformis*, *Phytolacca rigida*, *Sida carpinifolia*, *Rhus obtusifolia*, *Salix amphibia*, *Hamelia patens*, *Sagittaria lancifolia*, *Bidens leucantha*, *Solidago angustifolia*.

A. festiva Smith. Has been taken from Miami on north along the East Coast as far as Jupiter, and south as far as Homestead.

Visits to the following flowers have been noted: *Sabal Palmetto*, *Warea Carteri*, *Lepidium virginicum*, *Opuntia austrina*, *Croton linearis*, *Callicarpa americana*, *Chamaecrista aspera*, *Piriqueta tomentosa*, *Pycnothymus rigidus*, *Galactia floridana*, *Agalinis purpurea*, *Solidago angustifolia*, *Chrysopsis Tracyi*, *Aster* sp., *Bidens leucantha*, and *Helianthus debilis*. At Jupiter in the dunes of Jupiter Island it was visiting the flowers of *Chrysobalanus Icaco* (cocoplum) and *Jacquemontia reclinata*.

A. cuprea Smith. Specimens from Miami, South Miami and the dunes along the Atlantic at Miami Beach and on Key Biscayne at Cape Florida. Southward it was found at Homestead and the Royal Palm State Park, and northward at Lake Worth and Jupiter.

Flowers visited: *Warea Carteri*, *Lantana depressa*, *Chrysopsis Tracyi*, *Bidens leucantha*, *Helianthus debilis*, *Baccharis halimifolia*, *Solanum Wendlandi*. *Rhus obtusifolia*, and *Jacquemontia reclinata* (on dunes at Jupiter Island).

A. fulgida Smith. This species, which, on account of its large size and brilliant metallic coloration, is not easily overlooked, has been taken by the writer only occasionally, and not south of Miami, so far. My records are from the following localities: Sandy pine wood. in the northwestern part of Miami (visiting *Warea Carteri*), sandy pinewoods

southwest of Hollywood belonging to the "Scrub" type of vegetation (on *Polypteris integrifolia*), and sandy pine woods north of West Palm Beach (on *Solidago angustifolia*).

Agapostemon Smith.

A. splendens Lep. Not uncommon throughout the region. Specimens on hand from Miami, Miami Beach, South Miami, Homestead (29 miles southwest of Miami) and Hollywood (16 miles north of Miami). Females have been taken from the middle of March to the end of October, and males from the beginning of June to the beginning of December.

Flowers visited: *Phytolacca rigida, Opuntia austrina, Warea Carteri, Vernonia Blodgettii, Helianthus debilis* and *Bidens leucantha.*

Sphecodes Latreille.

S. ignitus Cockerell Described from a ♂. Type locality, Ocala, Fla., (**2**, 13).

The ♀ agrees very closely with the ♂, but is mostly larger. The species is easily recognized on account of the dark red thorax (metathorax entirely, or partly black), the black abdomen with a red base, and the prominent oval tubercle behind the middle ocellus. It shares the latter character with *S. clematidis* Robt. There is considerable variation in size and in the distribution of red on the thorax.

It is an inhabitant of the "Scrub" vegetation near Hollywood, the pine woods at Miami, South Miami and Homestead, and the sand dunes at Miami Beach.

Flowers visited: *Sabal Palmetto, Rhus obtusifolia, Warea Carteri* and *Polypteris integrifolia.* It was also observed feeding on honey-dew on the leaves of *Ficus altissima,* an ornamental tree infested with scale insects. Time of flight, March 31–December 28.

Perdita Smith.

Perdita sp. Most of the material was turned over to Prof. P. H. Timberlake, of the Citrus Experiment Station, University of California, Riverside, Calif., who has been making a special study of the bees of this genus. The species is new, and Prof. Timberlake has kindly consented to describe it The female collects her pollen exclusively from species of *Chrysopsis* (*Compositæ*) and an account of the distribution of this species along the East Coast of Florida will be found in the latter part of this paper, where the "Scrub" type of vegetation is being considered. It flies from about the beginning of September to the end of October.

P. halictoides Smith. A female collected at Coral Gables by Prof. J. F. W. Pearson, of the University of Miami. It was sent to Prof. Timberlake, to whom I am indebted for the following information: "It is the same species as the Bradley specimens from Coronado Beach, Fla. (collected May 5), and undoubtedly *P. halictoides* Smith. Mr. Schwarz compared one of Bradley's specimens with the type in the British Museum and found no difference." (See **29**, 155). The Coral Gables specimen was taken March 5.

Epeolus Latreille.

E. bifasciatus Cresson. Three males and two females were taken between February 10 and June 22, at Miami and South Miami, on the flowers of *Sabal Palmetto, Vernonia Blodgettii* and *Cirsium vittatum.* Two of them (♂ and ♀) have rust-colored instead of golden hairbands on pronotum and second abdominal segment, and Mr. H. F. Schwarz, of the American Museum of Natural History, has informed me that there are three specimens in the Museum's collection with bands of the same color, which were collected by Mrs. A T. Slosson at Lake Worth and Ormond, Fla

Robertson (**16** 116) considers this species an inquiline (parasite) of *Colletes latitarsis* Robt , which is also a member of our fauna.

E. zonatus Smith ♂ Described from St John's Bluff, East Florida. (**25**, 257). Prof. Robertson formerly treated it as a synonym of *E. scutellaris* Say (**14**, 343), in a recent publication, however (**16**, 278), he has it listed as a valid species.

I have never come across this species, but there are a number of Florida specimens in the collection of the American Museum of Natural History, and I am indebted to Mr. H. F. Schwarz for the following records: Miami, April 11 21, 1923 (Lutz and Schwarz); Royal Palm State Park, April 12 18, 1923 (Lutz and Schwarz); Dunedin, April 4, 1914 (probably Blatchley), Estero (Van Duzee); Ormond (Mrs. A. T. Slosson). According to Mr. Schwarz the Miami specimens were caught in the Brickell Hammock jungle. Based on a study of this series, M . Schwarz too considers *zonatus* distinct from *scutellaris* (in litt.).

Triepeolus Robertson.

T. rufithorax Graen. ♂ and ♀. Ent. News **39,** 279 (1928). Type (♀) and allotype (♂) deposited in the U. S. National Museum.

As far as we know, the bees of this genus are parasites of bees of the genus *Melissodes.* At Milwaukee, Wis., the writer witnessed the visits of *Triepeolus helianthi* Robt. to the nest of *Melissodes trinodis* Robt and found the larvæ of the former in the nest of the latter (**6**, 164). *T. rufithorax* is in all probability a parasite of *Melissodes communis* Cress. Of our three species of *Melissodes* (the next genus in the list) *communis* has the longest period of flight (March 21-November 14), and this corresponds with that of *T. rufithorax* (March 28-October 26).

Melissodes Romand.

M. communis Cress. Described from Georgia. Both sexes are on the wing throughout the warmer part of the year, the males from March 21-October 1 and the females from March 23 November 14. Specimens are on hand from Miami, South Miami and Miami Beach.

Flowers visited: *Sida carpinifolia, Heliotropium horizontale, Sabal Palmetto, Opuntia austrina, Croton linearis, Hyptis radiata, Crotalaria pumila, Bidens leucantha, Borrichia frutescens, Helianthus debilis, Flaveria linearis* and *Vernonia Blodgettii.*

M. petulca Cress. Described from Georgia.

To all appearances this is a rare insect in our region. Four specimens only have been taken, one at South Miami, May 1, 1917, and the remaining three May 4, 1927, at Cocoplum Beach (south of Coconut Grove) on the flowers of *Borrichia frutescens* (*Compositæ*).

M. perplexa Cress. var. This widely distributed bee, the range of which extends from Texas to Maine, has been observed at South Miami visiting exclusively the flowers of *Chrysopsis Tracyi* (*Compositæ*). The male has not been found. I sent two specimens (females) to Prof. Cockerell, requesting him to compare them with specimens of *perplexa* in his collection from other localities, and received from him the following information: "Your *M. perplexa* differ a little from the usual form in having a broader head (facial quadrangle broader) and I think rather rougher base of metathorax. I should hesitate to separate them unless you find the difference constant in a large series, and perhaps some difference in the males." He further states: "I think critical field studies will tend to increase the number of recognizable species or races, but from one or two specimens it is hard to estimate the value of slight differences. So I call your bees simply *perplexa* var. and am not sure (judging from what you send) that there is any constant Florida race or segregation. As the records stand, *perplexa* visits many plants, but mostly *Compositæ* (*Vernonia*, *Solidago*, *Aster*, *Rudbeckia*, *Lepachys*, *Helianthus*, *Silphium*, *Coreopsis*, *Bidens* and *Helenium*). I suppose that if one were trying to distinguish races or allied forms, it would be desirable to collect series separately from these plants."

According to the records from New Jersey, Maryland and Virginia, *perplexa* flies in August and September, while the variety of our region appears very late. Repeated observations made in 1924, '26 and '27 have shown it to be on the wing from about the beginning of November to the middle of December, at a time when its food-plant, *Chrysopsis Tracyi*, is at the height of its flowering season. It has not been seen to pay any attention to the flowers of any of the other species of *Compositæ* blooming in the same locality at the same time. In my neighborhood it obviously depends on *Chrysopsis Tracyi* for its pollen supply. It probably occurs elsewhere in the state and may be found visiting some other species of *Compositæ*.

Centris Fabricius.

C. versicolor Fabr. *C. errans* Fox, Proc. Acad. Nat. Sc. Phil **51,** 65, described from specimens collected by Mrs. A T. Slosson at Biscayne Bay, is a synonym (**11**, 561).

This is a tropical bee which is very widely distributed, from Florida on through the West Indies, Mexico, Central and South America to Argentina. A female from Brickell Hammock, April 19, 1923, at the flowers of *Bidens leucantha*, is the only specimen collected by the writer. It agrees very closely with the description of *errans*, and differs somewhat in face marks and color of legs and abdomen from a specimen received from the U. S. National Museum, the label of which bears the following information: Dominica, June–July H. W. Foote, Yale Exp. 1913.

Caupolicana Spinola.

C. (Megacilissa) yarrowi Cress.

Its occurence in Florida was reported in Ent. News IX, 128; collected by Mrs. Slosson. Cockerell has found it in New Mexico, visiting the flowers of *Datura* between daylight and sunrise. A single specimen, a ♀, was taken at South Miami at the same time of the day on the flowers of the introduced tropical vine *Antigonon leptopus* Hook. and Arn. The bees of this genus are nocturnal, some of the South American species flying throughout the night.

Coelioxys Latreille.

C. octodentata Say Custer has bred this parasitic bee from the cells of *Megachile brevis*, as reported by Hicks (**10**, 227). At Carlinville, Ill., Robertson found the host bee flying from May 15 to October 22, and the parasite from May 12 to October 19 In the Miami region *M. brevis* has been taken from March 27 to December 15 and *C. octodentata* from March 3 to November 1 The specimens of the latter are from the Royal Palm State Park, Homestead, South Miami, Miami and Hollywood. It is by far the most common species of *Coelioxys* of this region.

Flowers visited: *Bidens leucantha*, *Vernonia Blodgettii*, *Melanthera radiata*, *Sida carpinifolia* and *Oxypolis filiformis*.

C. dolichos Fox. (**4**, 107) Described from Florida (no locality given). Taken at Miami, Cocoplum Beach (south of Coconut Grove) and Homestead, from the flowers of *Bidens leucantha* and *Melanthera parvifolia*. Dates of capture January 28, March 25, July 2 and 3, November 3 and 8.

C. slossoni Viereck (**30**, 327) Type locality, Lake Worth, Fla. Males and females collected at Miami, Royal Palm State Park and Cape Florida (Biscayne Key) on the following dates: January 1, February 25, November 8, 20, 24. On two occasions visits were noted to the flowers of *Bidens leucantha*.

C. hunteri Crawf (**3**, 151) Type locality, Hearne, Texas. A single specimen, a ♀, March 20, 1920 at South Miami on the flowers of *Bidens leucantha*.

Lithurgus Berthold.

L. gibbosus Smith. Two males, March 15 and 31, and two females February 10 and March 6 at Miami and South Miami. Of these, a male and a female were visiting the flowers of the prickly-pear cactus (*Opuntia austrina*).

Megachile Letreille.

All of my material was sent to Prof. T. B. Mitchell of the North Carolina State College at Raleigh, who is engaged in a revision of the bees of this genus. His identification of the species has been of the utmost help to me. A species recognized as new will be described by him in a forthcoming paper.

M. xylocopoides Smith. This is a southern species whose range, according to information kindly furnished me by Prof. Mitchell, extends north to North Carolina at least.

It flies from about the end of February to the beginning of November. Both sexes were taken at Miami and South Miami. Flowers visited: *Poinsettia cyathophora*, *Citrus Limonum* (lemon) and *Bidens leucantha*.

M. morio Smith More tropical in its distribution than the foregoing. "Seems to be confined to the lower end of Florida" (Mitchell, in litt.). It has been found from February 25 to September 23 at the flowers of *Poinsettia cyathophora*, *Melanthera brevifolia* and *Bidens leucantha*. The specimens are from the following localities: Brickell Hammock (Between Miami and Coconut Grove) and the Snapper Creek Hammock on the East Dixie Highway (between Coconut Grove and Cutler).

M. pruina Smith. Miami, South Miami, Homestead, Royal Palm State Park. Males (*floridana* Robt. is the male) were taken from June 6 to October 31, and the females (*pinguis* Cress. is a synonym) from July 15 to October 17. Females from the shore vegetation along Biscayne Bay in the Brickell Hammock and at Cocoplum Beach (south of Coconut Grove) were visiting the flowers of *Dalbergia Ecastophyllum* and *Melanthera parvifolia*. Additional flowers visited were *Croton linearis*, *Galactia floridana* and *Vernonia Blodgettii*.

M. parallela Smith A female, Miami Beach, August 17, 1927, visiting the flowers of *Melanthera parvifolia*.

M. albitarsis Cress ♂. Found from March 25 to October 18 at South Miami, Chapman Field (near Cutler) and Homestead. Flowers visited: *Croton linearis* and *Bidens leucantha*.

M. optiva Cress. Flying from March 22 to November 2. Taken at Miami, South Miami, Cutler (Chapman Field) and the Royal Palm State Park, on the flowers of *Sabal Palmetto*, *Croton linearis*, *Morongia angustata*, *Crotalaria sp.* (cultivated in Chapman Field), *Bidens leucantha* and *Melanthera radiata*.

M. townsendiana Ckll. Known from the Southwest, and, as Prof. Mitchell informs me, also found at Galveston, Texas. I have both sexes from the dune vegetation at Miami Beach and Las Olas Beach (Fort Lauderdale), and have not come across it in any other type of vegetation. It visits the flowers of *Melanthera parvifolia* and the sunflower *Helianthus debilis*, mostly the latter. My dates of capture run from May 27 to September 22.

M. georgica Cress Miami, South Miami, Cutler (Chapman Field) and Hollywood, from April 14 to December 15. Flowers visited: *Galactia floridana*, *Crotalaria pumila*, *Crotalaria* sp. (cultivated at Chapman Field), *Melanthera radiata*, *Polypteris integrifolia* and *Laciniaria laevigata*.

M. pollicaris Say. Two males and a female at South Miami, June 14, 22 and 25, from the flowers of *Vernonia Blodgettii*.

M. inimica Cress. Miami (Brickell Hammock), Cocoplum Beach (south of Coconut Grove), Cape Florida (on Biscayne Key), and

Cutler (Chapman Field). Taken as early as February 10 and from then on in March, April and May, and again November 2. I have no records for the summer months. Visits were made to the flowers of *Crotalaria pumila*, *Bidens leucantha* and *Borrichia frutescens*.

M. petulans Cress. Miami, Miami Beach, South Miami, Cutler (Chapman Field) and Royal Palm State Park, from March 15 to November 25. Flowers visited: *Sabal Palmetto*, *Poinsettia cyathophora*, *Crotalaria* sp. (cultivated in Chapman Field), *Vernonia Blodgettii*, *Aster* sp., *Melanthera parvifolia* and *Bidens leucantha*.

M. mendica Cress. My records cover the period from May 11 to December 18 and show this to be our most common leaf-cutter bee. Specimens collected at Miami, Miami Beach, South Miami, Cutler (Chapman Field), Homestead and the Royal Palm State Park, on the flowers of *Philibertella clausa*, *Galactia floridana*, *Crotalaria* sp (cultibated in Chapman Field), *Vernonia Blodgettii*, *Melanthera parvifolia*, *Borrichia frutescens*, *Aster* sp., and *Bidens leucantha*.

M. brevis Say. Time of flight from March 27 to December 15. Miami, South Miami and Cutler (Chapman Field). Flowers visited: *Chamaecrista brachiata*, *Galactia floridana*, *Crotalaria pumila*, *Crotalaria* sp (cultivated in Chapman Field), *Vernonia Blodgettii* and *Melanthera radiata*.

M. generosa Cress Taken at Miami, Cocoplum Beach (south of Coconut Grove), South Miami and the Royal Palm State Park, from February 27 to September 6, visiting the flowers of *Poinsettia cyathophora* and *Vernonia Blodgettii*.

Megachile n. sp. One female captured on the flowers of *Borrichia frutescens* at Cocoplum Beach (South of Coconut Grove) June 5. Undescribed, according to Prof. Mitchell.

Heriades Spinola

H. crawfordi Graen ♂, ♀. Ent News **39,** 281 (1928) Type (♀) and allotype (♂) deposited in the U. S National Museum. Flies during the winter time. Localities and flower visits given with the description.

Osmia Panzer.

O. subfasciata Cress This species occurs in the sand dunes at Miami Beach and on Biscayne Key (across the Bay southeast of Miami), and visits the flowers of *Crotalaria pumila*. Dates of capture: February 8, 15, and March 17.

Stelis Panzer.

S. floridana Graen. ♂, ♀. Ent. News, **39,** 282 (1928). Type (♀) and allotype (♂) deposited in the U. S. National Museum. Five males and one female from Homestead, July 1916.

In a recent letter, Mr. H. F. Schwarz of the American Museum of Natural History has kindly informed me that he has come across two specimens in the Museum's collection, from Biscayne Bay, Florida, which he considers belonging to this species, although they do not agree with the description in all respects.

Anthidium Fabricius.

A. maculifrons Smith. Up to a short time ago, the bees of this species inhabiting the Eastern U. S. have been considered *cognatum* Cress. described from Georgia. Mr. H. F. Schwarz, who has given us a revision of the North American Anthidiine bees, has compared specimens of *cognatum* with the type of *maculifrons* in the British Museum, and shown the former to be a synonym of the latter (**21**, 369). It extends its range northward as far as Virginia and in the southwest into Mexico. Among the records given by Schwarz for Florida, there is one from the Royal Palm State Park. It is not uncommon in our region from about February 10 to November 2, and I have specimens from Miami, South Miami, Cutler (Chapman Field) and Homestead. It seems to favor the flowers of *Leguminosæ* on the following species of which it has been captured: *Petalostemon carneus*, *Galactia floridana*, *Crotalaria pumila* and a cultivated species of *Crotalaria* (Chapman Field). It has also been found visiting *Chamaecrista brachiata* (*Cassiaceæ*), *Vernonia Blodgettii* (*Compositæ*) and *Heliotropium horizontale*.

Heteranthidium Cockerell

H. ridingsii Cress. Described from Georgia, and, according to Schwarz, found also in Alabama and Texas (**18**, 5). I have three males and two females from South Miami, which were taken between March 31 and June 30, on the flowers of *Chamaecrista brachiata* and *Antigonon leptopus*, an ornamental vine introduced from tropical America. The females agree with the description in having dark legs, but in the males the tips of the femora and tibiæ are red.

Dianthidium Cockerell.

D. floridiense H. F. Schwarz ♂, ♀. Am. Mus Nov. No. 226, 5 (1926).

The numerous specimens studied by Schwarz were from various localities in Florida, from Sanford in the northern part, to the Royal Palm State Park near the southern tip. Some of them were from Biscayne Bay and Homestead. This bee flies from about the middle of February to the end of October. Visits were noted to the flowers of *Sabal Palmetto*, but mostly to the following *Compositæ: Vernonia Blodgettii*, *Mikania batatifolia*, *Polypteris integrifolia*, *Bidens leucantha*, *Laciniaria gracilis*, *Pterocaulon undatum* and *Melanthera parvifolia*.

Anthidiellum Cockerell.

A. perplexum Smith. According to Schwarz (**19,** 18), its known range extends north to Southern Pines, N. C. Among the material seen by Schwarz was a ♂ from Miami. I have found both sexes at Miami, Miami Beech, South Miami, Cutler (Chapman Field), Homestead, and the Royal Plam State Park. Time of flight: February 10 to November 2. Flowers visited were those of *Sabal Palmetto*, *Crotalaria pumila* and *Helianthus debilis*.

A. notatum rufimaculatum H. F. Schwarz. ♂, ♀. Am. Mus. Nov. No. 226, 18–19 (1926).

The localities listed by Schwarz for this new variety are Miami, Homestead and the Royal Palm State Park. It is rather common throughout, and has been taken by the writer from January 21 to December 15. Flowers visited: *Crotalaria pumila*, *Petalostemon carneus*, *Galactia floridana*, *Parosela domingensis*, *Croton linearis*, *Sesuvium Portulacastrum*, *Melanthera parvifolia* and *Antigonon leptopus* (an ornamental vine). Some of the specimens collected by Lutz in the Miami region were visiting the flowers of Sumac (reported by Schwarz).

Ceratina Latreille

C. dupla Say. Both sexes of this common and widely distributed species fly throughout the year. Nests with eggs and larvæ may be found at any time in the dry stems of the Sumac, *Rhus obtusifolia* and other pithy plants. Visits to the flowers of the following have been noted: *Salix amphibia*, *Sinapis arvensis*, *Opuntia austrina*, *Pycnothymus rigidus*, *Galactia pinetorum* *Aster concolor*, *Bidens leucantha*, *Chrysopsis Tracyi* and *Cirsium pinetorum*.

C. cockerelli H. S. Smith. (Changed from **C. lunata** H. S. Smith, preoccupied). Type locality Fedor, Leo County, Texas (**26**, 119). Five males and two females have been taken in the dune area at Miami Beach, July 29, 1916 and April 12, 1918, some of them at the flowers of *Polygala cumulicola* Small, a new species found by Small in that locality (**22**, 381). Another male was caught in the house, at South Miami, towards evening, January 11, 1921.

In each of the males the white clypeal mark does not cover the entire clypeal surface as in the type material. There is a line along the base from which a rectangular median mark projects upwards, the whole resembling an inverted "T."

Xylocopa Latreille.

X. micans St. Farg Cockerell (**2**, 5) has seen a specimen from Homestead. I have both sexes from the Royal Palm State Park, South Miami and Miami (Brickell Hammock). It flies from about the end of February to the end of November. Flowers visited: *Serenoa serrulata*, *Sabal Palmetto*, *Philibertella clausa*, *Solanum bahamense*, *S. Wendlandi* (an ornamental tropical vine), *Chamaecrista brachiata*, *Crotalaria pumila*, *Dalbergia Ecastophyllum* and *Bidens leucantha*.

Bombus Latreille (**Bremus** Panzer).

In Franklin's "Bombidæ of North America," the following four species are credited to Florida: *americanorum*, *impatiens*, *separatus*, and *fraternus*. The first three occur in the Miami region, *fraternus* Smith (*scutellaris* Cress.) has been found by the writer as far south as Childs, which is situated a short distance northwest of Lake Okeechobee at the southern end of the hilly country known as the "Ridge Section."

B. americanorum Fab. (*pennsylvanicus* DeG.) is our most common bumblebee. Females (queens) have been taken as early as February 12 and as late as November 30. There is a period of hibernation, the beginning of which is determined by the first cold spell (about 40° F. or below) of the winter season. In 1927, for example, bees of this species were daily visitors to a group of flowers of *Antigonon leptopus* (an introduced tropical vine belonging to the *Polygonaceæ*) near our house up to the end of the first week in November, when cold weather set in, and put an end to their appearance. Workers have been seen from June 6 to the beginning of October, and males from June 6 to the middle of October.

Flowers visited: *Chamaecrista brachiata, Opuntia austrina, Vernonia Blodgettii, Cirsium pinetorum, Lantana ovatifolia* and *Morinda Roioc*. They are attracted to quite an extent by the flowers of the various cultivated species of *Citrus* (grapefruit, orange, lemon and lime), as also by those of the ornamental tropical vines *Solanum Wendlandi* and *Antigonon leptopus*.

B. impatiens Cress. This has been found only occasionally at Miami and South Miami, in July, August and October, on the flowers of *Bidens leucantha, Conoclinium dichotomum* and *Solanum Wendlandi*. No males have been seen.

B. separatus Cress. Belongs to the subgenus *Bombias* Robertson. Like the preceding species, it is poorly represented in our fauna. Three females were collected at South Miami in April and June, at the flowers of *Morongia angustata* and *Solanum Wendlandi*. To my great surprise I came across a ♀ December 22, 1926, collecting pollen on *Pontederia cordata* (pickerel weed) which was growing in a wet ditch along a road in the Everglades several miles west of South Miami.

Psithyrus Lepeletier

P. variabilis Cress Has not been reported from Florida. It is a parasite in the nests of *Bombus americanorum* (the common bumblebee of our region), according to Frison (**5**). The only specimen the writer has seen, so far, is a female taken at Homestead, July 21, 1916.

Apis Linnaeus.

A. mellifera Linn Honey-bee. Common throughout, both cultivated and wild. As elsewhere, it often monopolizes flowers with a rich supply of pollen and nectar to such an extent that other visitors are nearly excluded. It visits a great variety of flowers, is a regular visitor to the flowers of many of our fruit trees (Citrus fruits, avocadoes, mangoes, etc.), and for this reason is kept in many of the groves.

Bee Fauna of the Royal Palm State Park.

The "Natural History of Paradise Key and the nearby Everglades of Florida," published in 1919 by W. E. Safford (**17**), contains a lot of interesting information on the plant and animal life, and various other topics. This State Park is situated 44 miles southwest of Miami, and covers an area of about three square miles. Within its confines three distinct types of vegetation are represented. The limestone island called Paradise Key is covered mostly by a Tropical Hammock, with a stretch of Pinewoods in one corner. The wet lowlands surrounding Paradise Key belong to the Marl Prairie vegetation.

The species of bees reported by Safford are as follows:

Bombus americanorum (*pennsylvanicus*), *Xylocopa micans*, *Megachile pollicaris*, *Coelioxys dolichos* and *Augochlora* sp.

To these may be added the following, three of which (Anthidiinæ) have been reported by Mr. H. F. Schwarz:

Hylaeus schwarzii, *Augochlora pura*, *A. cuprea*, *Coelioxys octodentata*, *C. slossoni*, *Megachile pruina*, *M. optiva*, *M. petulans*, *M. mendica*, *M. generosa*, *Anthidium maculifrons* (Schwarz), *Dianthidium floridiense* (Schwarz). *Anthidiellum notatum rufimaculatum* (Schwarz) and *A. perplexum*.

Seasonal Distribution.

Some of the species fly throughout the year, for three species I have records for the cooler season only, the majority, however, appear on the wing towards the end of the winter or early in the spring, and carry on their activities during the warmer months of the year until late in the fall.

Period of Flight Covering the Entire Year.

Colletes latitarsis. Specimens of the bee and of its food-plant, *Physalis viscosa*, may be found at any time during the winter, but both appear in greater numbers during the warmer months.

Halictus. All of the species, the records for which are complete, fly the year round, with the exception of *halophilus*.

Augochlora. The four species listed for the region belong to this group.

Ceratina. Our common species *dupla* is common at all times. *Cockerelli* has been taken from January 11 to July 29, but probably flies during the rest of the year.

Flying During the Cooler Season.

Hylaeus schwarzii: October 1 May 2.
Coelioxys slossoni: November 8-February 25.
Heriades crawfordi: October 27-April 6.

The periods of flight given for these species are based on repeated observations I have not yet succeeded in finding them at any other time.

FLYING DURING THE WARMER SEASON.

Colletes. Mandibularis is a vernal species (March 30–June 11) and so is probably *distinctus*, which has been taken April 21 and May 1.

Halictus halophilus (April 20 October 23) is the only species of the genus restricted in its appearance to the warmer months.

Agapostemon splendens: March 14–December 4.

Sphecodes ignitus: March 31 December 28.

Perdita. P. sp. (undescribed), flying throughout September and October. *P. halictoides* is a vernal species. One female taken at Coral Gables, March 5. Two females were collected by Dr. Bradley at Coronado Beach (Florida East Coast south of Daytona), May 5, 1916, as reported by Prof. Timberlake (**29**, 155)

Melissodes. Communis, March 21 November 14. *Perplexa* var. is autumnal (November and first half of December). For *petulca* the records are incomplete (May).

Triepeolus rufithorax: March 28–October 26. Is probably a parasite of *Melissodes communis* (March 21-November 14).

Epeolus bifasciatus. Taken from February 10 to June 22. If it is a parasite of *Colletes latitarsis*, as suggested by Robertson, it probably flies much longer.

Megachile. Some of the species, like *morio*, *xylocopoides*, *inimica*, and *generosa*, start in February, others in March or April. *Townsendiana* and *mendica* do not seem to appear before May, and for *pruina* and *pollicaris* the earliest records are for June. Many of the species fly until late in the fall. The latest dates are as follows: *georgica*, December 15, *brevis* December 15, *mendica* December 18.

Coelioxys. Our common species, *octodentata* (a parasite of *Megachile brevis*), flies from March to November. The records for *dolichos* indicate a flight from the end of January to the second week in November.

Lithurgus gibbosus is an early flier (February 10-March 31), *Osmia subfasciata* likewise (February 8 March 17). I suspect, however, that my records for both of these are incomplete.

Heteranthidium ridingsii, the least common of our *Anthidiinæ*, flies in the spring (March 31-June 30). The four remaining species start early and finish late, as the following records show: *Anthidium maculifrons*, February 10-November 2; *Dianthidium floridiense*, February 10–October 30; *Anthidiellum notatum rufimaculatum*, January 24–December 15; *A. perplexum*, February 10-November 2.

Stelis floridana. There is only one record for this parasitic bee: July 20, 1916.

Xylocopa micans: February 25 November 24.

Bombus. The earliest date for the female (queen) of *americanorum*, our common bumblebee, is February 12, the latest November 30. The two remaining species are comparatively rare, and for these the

early and late records are as follows: *impatiens*, July 20 October 21; *separatus*, April 8–December 22. As to the latter date, it was stated in the first part of this paper that the finding of a bumblebee collecting pollen at this time of the year came entirely unexpected The question arises whether this particular species (*separatus*) is a hardier insect than *americanorum*, and normally carries its nesting activities over into the cooler season, or whether we are dealing with the exceptional behavior of an individual.

Psithyrus variabilis. This parasite of *Bombus americanorum* has been met with on one occasion only: July 21, 1916.

Types of Vegetation

The vegetation of the Miami region is made up of several distinct types, a discussion of which is deemed essential to an understanding of the environmental conditions under which the bees live. The latter are in their majority not dependent upon any particular type of vegetation, they show a more or less even distribution throughout wherever suitable food-plants and nesting sites exist. There are, however, a number of species which, according to the information on hand, are restricted to certain well-defined areas.

The following six types of vegetation are to be considered*, and for each a few of the plants mentioned, the flowers of which seem to be of especial importance in the economy of the bees.

1. Pinewoods.

The characteristic tree of the Pinewoods is *Pinus caribaea* (Caribbean pine), and this is the only pine found south of Miami Palms, notably the saw-palmetto (*Serenoa serrulata*) and the cabbage palmetto (*Sabal Palmetto*), are prominent, and, in some places, even dominant members of the undergrowth, and their flowers are eagerly visited by bees and other insects. There is a great variety of herbs occupying the available spaces between the larger elements of the flora, and the flowers of some of these are very attractive to bees.

Among the *Compositae* (*Carduaceae* according to Small) the following species deserve special mention: *Bidens leucantha*, *Vernonia Blodgettii* and *Chrysopsis Tracyi*.

Bidens leucantha: This is an obnoxious weed locally known as "Spanish needles," a native of Tropical America, and, according to Small, widely distributed in tropical countries. Of extremely common occurrence, it inhabits roadsides and waste grounds in the Pinewoods, the Hammocks and the drier portions of the Marl Prairies. Its conspicuous heads with the white rays and yellow tubular florets offer throughout the year, and especially during the summer months, a never-failing supply of pollen and nectar. It is a most important

*See Dr. R. M. Harper, Natural Resources of Southern Florida. From the 18th Annual Report of the Florida State Geological Survey (1927).

food-plant of our native bees, and stands at the head of the list, so far as the number of visitors is concerned. Twenty-five species belonging to the following genera were observed: 1 *Halictus*, 3 *Augochlora*, 1 *Agapostemon*, 1 *Triepeolus*, 4 *Coelioxys*, 9 *Megachile*, 1 *Dianthidium*, 1 *Ceratina*, 1 *Centris*, 1 *Xylocopa*, 1 *Bombus*, 1 *Apis*.

Vernonia Blodgettii: On the numerous purple heads fourteen species of bees of the following genera were taken in May and June: 1 *Agapostemon*, 1 *Epeolus*, 1 *Triepeolus*, 1 *Melissodes*, 1 *Coelioxys*, 6 *Megachile*, 1 *Anthidium*, 1 *Dianthidium*, 1 *Bombus*.

Chrysopsis Tracyi (Golden aster). This is mainly an autumnal species which reaches its maximum from about the beginning of September to the middle of December, when patches of the conspicuous yellow heads appear on the pinelands. Scattered specimens, however, may be found in bloom during the rest of the year. Nine species of bees have been taken as visitors, and two of these, *Melissodes perplexa* and *Perdita* sp. (an undescribed species), obtain their pollen exclusively from these flowers.

The cabbage-palmetto (*Sabal Palmetto*) produces small sweet-scented flowers in great abundance, which are visited chiefly on account of their nectar. Eleven species of bees, ranging in size from the small *Halictus longiceps* to the large carpenter bee, *Xylocopa micans*, were taken on the flowers.

The leguminous plants, *Crotalaria pumila* (rattle box) and *Galactia floridana* (milk-vetch) are both quite attractive to bees. *Crotalaria pumila*, a weed with yellow flowers introduced from tropical America, is of common occurrence. *Galactia floridana* is a purple-flowered prostrate vine growing in patches. The closely related *G. pinetorum*, with smaller flowers is also an inhabitant of the Pinewoods.

Croton linearis (Fam. *Euphorbiaceæ*), a small shrub, has inconspicuous white flowers with easily accessible nectar, which attract bees of the genera *Halictus*, *Augochlora*, *Melissodes*, *Megachile*, *Heriades* and *Anthidiellum*.

Opuntia austrina, the only prickly-pear cactus of our Pinewoods, has large bright-yellow flowers with numerous stamens, but without nectar. This is a typical pollen-flower and its abundant supply of pollen attracts female bees of all sizes.

2. Tropical Hammocks.

Dense forests composed mainly of tropical vegetation (trees, shrubs, climbing vines and herbs) are scattered throughout the region, especially south of Miami. They are locally called "hammocks." Some are very small, while others, like the Brickell Hammock (along the Bay north of Coconut Grove) and the Royal Palm State Park (44 miles southwest of Miami) cover large tracts. The spaces between the trees are occupied mostly by climbers (lianas), the whole forming a more or less impenetrable jungle which receives very little light from above on account of the dense covering of the tree tops. For this reason shrubs and herbs thrive most abundantly in open spaces or along the margins. Roads leading through the "hammock" are invariably bordered by a luxuriant roadside vegetation. A very

characteristic feature is the number of epiphytes (so-called "air-plants") attached to the trunks and limbs of living and dead trees, consisting mostly of ferns, orchids and bromeliads (pineapple family). Bees are, as a rule, not found in the intensely shaded interior of a hammock, where there are few flowers to attract them; but, wherever flowers are plentiful, as along the margins and the roadsides, bees may be as numerous as in the Pinewoods, and many of the species inhabiting the latter are found here. The weed, *Bidens leucantha*, referred to above (under "Pinewoods") occurs in great numbers in such open situations. Of the native hammock plants attractive to bees *Melanthera parvifolia* (*Compositæ*) and *Poinsettia cyathophora* (*Euphorbiaceæ*) may be cited. The first-named forms large patches with very numerous heads of small white tubular florets, on which eight species of bees were taken. Not one of these visitors, however, is a typical inhabitant of the hammock. Offering an ample supply of pollen and nectar, the flowers of *Poinsettia cyathophora* attract insects of various orders. Seven species of bees were noted, one of which, *Megachile morio*, is distinctly tropical in its distribution, and has not been found by the writer outside of the Tropical Hammocks, so far *Centris versicolor*, a single specimen of which was taken in Brickell Hammock on the flowers of *Bidens leucantha*, is also a species of the tropics, ranging southward to Argentina. I have repeatedly watched the flowers of hammock trees of various sizes, and to my great surprise found a scarcity or even lack of visitors. Large trees that had been tipped over by the hurricane of 1926 and were still alive, and blooming the following season, made it possible for me to observe the flowers at close range

3. Marl Prairies.

The pinelands of the Miami region are situated on a broad elevated strip along the coast, and west of these are the lowlands known as the "Everglades," which Harper (**9**, 124) calls "the largest saw-grass marsh in the world." The dominating plant, especially in wet situations, is a large sedge, *Mariscus jamaicensis* (saw grass) From the Everglades numerous arms of varying width run out between the island-like pinelands towards the coast, and these are called "Marl Prairies" on account of the marly character of the soil.

Baccharis halimifolia (locally known as "glade myrtle") is a small tree belonging to the *Compositæ*, which occurs in great abundance. The innumerable white heads of this dioecious plant form a very conspicuous covering of the upper parts, from about the middle of October to the middle of December. The sweet-scented flowers are visited by bees and other kinds of anthophilous insects in large number. *Sagittaria lancifolia* (arrowhead), a common inhabitant of wet grounds, produces large white flowers which are especially attractive to the bee *Hylaeus schwarzii* Ckll. Once only have I come across this bee visiting the flowers of another plant, viz. *Bramia Monniera*, which too is a species of the Marl Prairie. Robertson (**5**) has taken *Hylaeus schwarzii* at the flowers of *Prunus umbellata*, *Eriocaulon sp.*, *Utricularia inflata*, *Castalia reniformis* and *Nymphaea advena* at Inverness and Orlando, Florida, both of which are in the Austroriparian zone. *Eriocaulon*

occurs usually in low grounds, *Utricularia*, *Castalia* and *Nymphaea* are decidedly hydrophytic. I have found *Hylaeus schwarzii* at Miami, South Miami and the Royal Palm State Park on numerous occasions, and always in moist or wet habitats, and do not hesitate to consider it a characteristic species of the Marl Prairies of the Miami region.

4. Coast Prairies.

On account of the salty condition of the soil, the low prairies along the shores of Biscayne Bay are inhabited by salt-loving plants (halophytes). Of the Coast Prairie type of vegetation Harper (**9**, 180) states that "it has been confused with the Everglades by some writers, and its inland edge does not differ much from the southern edge of the Everglades, but the Everglades are never touched by saltwater."

North of the large hammock at Cutler (about 9 miles south of Miami) there is a considerable portion of shoreland of the Coast Prairie type. South of the canal leading into Chapman Field (in the northern part of which the Plant Introduction Garden of the U. S. Dept. of Agriculture is located) a broad belt of mangroves (*Rhizophora mangle*) occupies the wet land and extends out into the shallow water, while in the slightly higher and drier situations the black mangrove (*Avicennia nitida*), white mangrove (*Laguncularia racemosa*), and the button-wood (*Conocarpus erecta*) are the characteristic plants of larger size. Farther inland where the soil is markedly drier, *Baccharis halimifolia* (mentioned above under "Marl Prairies") grows in profusion The following halophytic herbs, the flowers of which are visited by bees, occur here: *Borrichia frutescens*, *Sesuvium maritimum*, *Heliotropium curassavicum* and *Bramia Monniera*. *Borrichia frutescens* (*Compositæ*) has large heads with yellow rays, on which middle-sized bees (species of *Melissodes*, *Megachile* and *Triepeolus*) are found. The other halophytes mentioned are low plants with small flowers, and these are visited by the small bee *Halictus* (*Chloralictus*) *halophilus*, the type specimens of which were taken by the writer in this locality. Later on he has come across it on a narrow peninsular strip projecting from the northern end of Chapman Field out into Bay Biscayne, as also several miles farther north at Cocoplum Beach. In both places it was visiting the flowers of *Sesuvium Portulacastrum* (Sea-purslane) and the spurge *Chamaesyce buxifolia*, two additional halophytes. In the Miami region the bee *Halictus halophilus* seems to be confined to the Coast Prairie type of vegetation, and probably occurs in other regions along the coasts of sub-tropical Florida wherever the corresponding type of vegetation exists.

5. Dune Vegetation.

Opposite Miami, between the eastern shore of Biscayne Bay and the Atlantic Ocean, is a narrow barrier beach upon the southern end of which the city of Miami Beach has been built. This is a southern extension of the barrier beach along the Florida East Coast, and the two keys immediately south of Miami Beach (Virginia Key and Biscayne Key with Cape Florida at its southern tip) are continuations of the same costal strip. The more elevated portions of the dunes along the

Atlantic shore are out of reach of the waves of ordinary storms, but are subject to spray, and are inhabited by a number of halophytic plants. The largest native plants on the dunes are the sea-grape (*Cocolobis uvifera*), the Spanish bayonet (*Yucca aloifolia*), the bay-cedar (*Suriana maritima*), and *Tournefortia gnaphalodes*. Two large trailing vines, *Ipomoea Pes-capræ* (goat's foot morning glory) and *Canavali lineata* (a bean of West Indian origin), are very conspicuous elements of this type of vegetation.

The bees inhabiting the dunes have been taken mostly on the flowers of *Helianthus debilis* (beach sunflower), *Alternanthera floridana* and *Crotalaria pumila*, a leguminous weed considered previously under Pinewoods vegetation. *Helianthus debilis* has large yellow rays and is more attractive to visitors than any other dune flower. The small and very inconspicuous flowers of *Alternanthera floridana* are visited by the small bees *Halictus marinus* and *H. lepidii*. There are three bees peculiar to the dunes, which I have never succeeded in finding in any of the other types of vegetation. These are *Megachile townsendiana* on *Helianthus debilis* at Miami Beach and Las Olas Beach (at Fort Lauderdale); *Osmia subfasciata* on *Crotalaria pumila* at Miami Beach and on Key Biscayne, and *Halictus marinus* on *Alternanthera floridana*, *Helianthus debilis* and *Sesuvium Portulacastrum* at Miami Beach, Key Biscayne, Golden Beach and Las Olas Beach.

6. The "Scrub."

According to Harper (**9**, 79) "the driest and poorest soils in South Florida, consisting almost entirely of white quartz sand, are usually occupied by a type of vegetation known as "scrub." He points to its occurrence in the Lake Region of Central Florida, and as a narrow strip along the East Coast as far south as Dade County. In 1921 Small (**24**, 89) wrote as follows: "It seems that the southern limit of the "scrub" on the eastern coast is just west of Lemon City, between three and four miles north of Miami. The characteristic plant-association was there, excepting spruce-pine (*Pinus clausa*) which, however, was reported from that region not many years ago."

I have not been able to find any remnants of the "Scrub" in this particular locality, and believe that it has been wiped out by the extensive real estate activities of the last few years. There is, however, a small area of "Scrub" southwest of Hollywood, (16 miles north of Miami) which the writer has visited on several occasions. The two following very characteristic plants of the "Scrub" are still in existence: *Pinus clausa* (scrub-pine or spruce-pine) and *Ceratiola ericoides* (rosemary), and a number of other species usually associated with the "Scrub" are there. An undescribed species of the bee genus *Perdita* which visits exclusively flowers of the genus *Chrysopsis* (*Compositæ*) was found there, and I have been able to trace its occurrence in the "Scrub" as far as Stuart, which is 100 miles north of Miami. In the northwestern section of the city of Miami (S. E. corner of N. W. 7th St. and 22nd Ave.) there is a small area of vegetation on pure sand, where I have repeatedly found this bee on *Chrysopsis Tracyi*, the only species of

Chrysopsis in that locality. Another bee, *Augochlora fulgida*, occurs there, and in the "Scrub" near Hollywood and at West Palm Beach, but neither this nor the *Perdita* sp. have been met with in the Pinewoods on the Miami limestone south of the city of Miami.

LITERATURE.

1. **T. D. A. Cockerell.** 1904. Some little-known bees of the genus Colletes. Ent. News, **15,** 276-277.
2. 1922. Bees in the collection of the U. S. Nat. Mus. Proc. U. S. Nat. Mus. **60,** Art. 18, 1-20.
3. **J. C. Crawford.** 1914. Some species of the bee genus Coelioxys. Ann. Ent. Soc. Am. **7,** 148-159.
4. **W. J. Fox.** 1890. Description of three new Hymenoptera. Ent. News, **1,** 106-108.
5. **J. H. Frison.** 1916. Note on the habits of Psithyrus variabilis. Bull. Brook. Ent. Soc. **11,** 46-47.
6. **S. Graenicher.** 1905. Some observations on the life history and habits of parasitic bees. Bull Wis. Nat. Hist. Soc. **3,** 153-167. Pl. I.
7. 1927. Bees of the genus Halictus from Miami, Florida. Psyche, **34,** 203 208.
8. 1928. New bees from the Miami Region of Florida. Ent News, **39,** 279-281.
9. **R. M. Harper.** 1927. Natural Resources of Southern Florida. 18th Ann. Rept. Fla. St. Geol. Surv.
10. **C. H. Hicks,** 1926. Nesting habits and parasites of certain bees of Boulder Co., Colorado. Univ. Col. Stud. 217 252.
11. **F. A. Lutz** and **T. D. A. Cockerell.** 1920. Notes on the distribution and bibliography of N. Am. bees. Bull. Am. Mus. Nat. Hist., **42,** 491-641.
12. **C. H. Merriam.** 1891. The geographical distribution of life in N. Am. Smiths. Rept., 1891, 365 415.
13. **C. W. Metz.** A revision of the genus Prosopis in N. Am. Trans. Am. Ent. Soc., **37,** 85-156. Pl. II-IX.
14. **Chas. Robertson.** 1897. N. Am. bees. Trans. Acad. Sc. St. Louis, **7,** 315 356.
15. 1925. Phenology of inquiline and nest-making bees. Psyche **33,** 116 120.
16. 1927. Florida flowers and insects. Trans. Acad. Sc. St. Louis, **25,** 277 324.
17. **W. E. Safford.** 1919. Nat. Hist. of Paradise Key and the nearby Everglades of Florida. Publ. 2508, Smiths. Rept. 1917, 377-434; 64 plates.
18. **H. F. Schwarz.** June, 1926. N. Am. bees of the genus Heteranthidium. Am. Mus. Nov. No. 218.
19. October, 1926. N. Am. Dianthidium, Anthidiellum and Paranthidium. Am. Mus. Nov. No. 226.
20. March, 1927. Additional N. Am. bees of the genus Anthidium. Am. Mus. Nov. No. 253.
21. 1928. Bees of the subfamily Anthidiinae etc. Journ. N. Y. Ent. Soc., **36,** 369-418; 2 pl.
22. **J. K. Small.** 1913. Flora of Miami
23. 1924. Plant novelties from Florida. Bull. Torr. Bot. Cl., **51,** 379 393.
24. 1924. The land where spring meets autumn. Journ. N. Y. Bot. Gard., **25,** 53-94.
25. **F. Smith.** 1853. Catalogue Hymenopt. Brit. Mus.
26. **H. S. Smith.** 1907. Contribution to a monograph of the Ceratinidae of North and Middle Am. Trans. Am. Ent. Soc., **33,** 115 124. Pl. III.
27. **M. H. Swenk.** 1908. Specific characters in the bee genus Colletes. Contr. Dept. Ent. No. 1, Univ. Nebr., 43-102. Pl. I-III.
28. 1925. Two new bees of the genus Colletes, oligotropic upon Petalostemum. Am. Mus. Nov. No. 186.
29. **P. H. Timberlake.** 1928. Bees of the genus Perdita in the J. C. Bridwell collection. Proc. Haw. Ent. Soc., **7,** No. 1, 151-161.
30. **H. L. Viereck.** 1902. Descriptions of N. Am. bees. Can. Ent., **34,** 325-331.

CONTRIBUTION TO A KNOWLEDGE OF THE SPINDLE WORM, ACHATODES ZEAE (HARRIS.)

(Lepidoptera, Noctuidæ.)

E. P. BREAKEY
Wisconsin Department of Agriculture and Markets

The spindle worm, *Achatodes zeæ* (Harris), has been known to taxonomists since 1841. Accounts of it have frequently appeared in economic literature, but much uncertainty exists as to its economic status, and only fragments of its life history have been recorded. Since these studies were undertaken Balduf (1) has noted certain important elements of its seasonal history in connection with his observations on its parasites. The spindle worm first claimed the writer's attention late in the spring of 1927, when large numbers of them were found boring in the shoots of the common elder, *Sambucus canadensis* L., near Madison, Wisconsin. Data gathered would indicate that while *A. zeæ* may be considered a potential pest of certain crops in some localities it rarely attacks these in its natural environment.

The first account of the spindle worm to be found in the literature is that of Dr. T. W. Harris. On page 319 of the 1841 edition of his Insects Injurious to Vegetation the species is described under the name of *Gortyna zeæ*. Later it was transferred to the genus *Achatodes* of Guenée where it has remained

DISTRIBUTION AND HOST PLANTS.

Achatodes zeæ has been recorded from Maine, Massachusetts, New York, New Jersey, Ohio, Ontario, Indiana, Illinois, Iowa and Louisiana. In addition the writer has found it well distributed in Wisconsin and believes that its range will prove to be coextensive with that of its natural host plant, *Sambucus canadensis* L. Spindle worms have not been found in the shoots of the red-berried elder, *S. racemosa* L., although they have been sought in well developed stands of this plant. The fact that the latter has reached a more advanced stage in

development by the time the young caterpillars are about in the spring may account for its freedom from attack, for evidence gathered indicates that they find difficulty in entering a shoot, the exterior of which has become hard and woody. The difference that exists in the piths of the two plants may be a factor as that of the red-berried elder is tough and brown.

ECONOMIC HISTORY

Occasionally the larvæ of *Achatodes zeæ* are found feeding in the stems of other plants. We learn from Dr. Harris' account (5) that it was known to the farmers and gardeners of Massachusetts as the spindle worm from its destruction of the spindle of the corn, but that its attacks usually began before the spindle arose much above the tuft of leaves in which it was embosomed. We are also told that it was known to attack the stems of Dahlia and had been found in the pith of elder.

Smith (8) records a communication from Dr. F. H. Chittenden in which we are informed that this is one of the cases in which Dr. Harris was wrong, that *A. zeæ* feeds exclusively, so far as records go, in the stems of elder, and that any records of it injuring corn or strawberry, are in his (Chittenden's) opinion, incorrect. It is also pointed out that the true culprit found attacking such crops is *Papaipema nitela* or *nebris*, and that the species mentioned by Harris refers to both.

After examining the citation given by Dr. Chittenden, the writer is convinced that in this instance Dr. Harris was not confused as to the identity of the two insects he was considering. The description of the spindle worm given on pages 438 and 439 of the above citation, though brief, fits the larva of *A. zeæ* very well. After completing his account of this insect, Harris turned his attention to another caterpillar (p. 440) which he states is something like the spindle worm. We are told that this particular caterpillar had often been found by farmers in potato stalks, and that he himself had taken it from *Chenopodium*. Since the transformation of this caterpillar had not been observed, it was not given a name, but it is evident from his account and drawing that he had before him the larva of *Papaipema sp.*, and that he was fully aware it was not the spindle worm.

The detailed description written by Felt (4) for the half grown spindle worm. however, is obviously of another species.

Ellis (2) records an instance where eight young spindle worms were found in an equal number of sweet corn plants on May 28. The corn had not reached the spindle stage, but the larvæ were in well-defined burrows and were headed upward in these tunnels. The insect has also been recorded as injuring corn along the edge of a field near an elder thicket in Iowa (3)

No records of the spindle worm injuring corn in Wisconsin can be found, but on June 8, 1928, the writer removed three larvæ from as many Dahlia plants at Janesville. These plants were small and were near a well developed growth of elder.

METHODS.

The abundance of the material together with its accessibility contributed much toward the success of making detailed observations of the activities of *A. zeæ* under natural conditions. It has been possible to supplement these with observations made of specimens in confinement. Records kept for the insects in confinement gave such information as the length of the adult's life, the number of eggs laid, the effect of fertility on fecundity, and others that were scarcely anticipated. Extensive collecting was done, since a census of the natural enemies that might be attacking the species was desired, in addition to the material needed for stocking the cages.

From the adults that emerged in 1929 the following groups were selected for more detailed observation: Six fertile females, six males, and six virgin females. Each moth was confined soon after eclosion in an individual cage made from a tin box, one side of which had been provided with a screened opening. The bottom of each cage was covered with three or four thicknesses of toweling paper cut to fit. Food was supplied in the form of loaf sugar that had been dipped in water The females were provided with artificial egg repositories described elsewhere. In both 1928 and 1929, moths were confined in larger cages where observations of a more general nature could be made. All cages were kept under a shelter which experienced the same temperatures as those prevailing outside.

EGG REPOSITORIES.

After discovering that the moths seek close crevices or folds in which to oviposit, special egg repositories were provided with the aim of making the eggs more accessible for observation. A small sheet of paper 10.5 × 14 cm. was taken from a desk pad and accordion-pleated crosswise with centimeter folds. The pleats were then appressed at one end and secured with a paper clip. The result was a small paper fan which was placed in the cage, flaring end down. Because of the ease with which the repositories were constructed, they were replaced as often as desired. When one was removed from a cage, such information as the date and cage number was written on one of the lower corners, the clip was removed and it was stored for future observation. The moths always placed their eggs between the closely appressed folds near the clip. By pulling the pleats apart the egg masses were exposed, although fibers from the adjacent fold sometimes had to be removed with a pair of fine tweezers before an unobstructed view of the eggs could be had.

SEASONAL HISTORY AND HABITS.

Achatodes zeæ has but one generation a year and shows a nicety of adjustment to the seasonal development of the host plant. At Madison the eggs are laid, for the most part, during

the last half of July. Winter is passed as a developing embryo within the chorion of the egg. Hatching of the eggs is irregular, but takes place mostly during the last part of April and the first part of May. By the end of June larval growth is at an end and pupation is taking place. The pupal stage lasts about 15 days. Oviposition begins shortly after the adults emerge.

Location of the Eggs.

The eggs of *A. zeæ* have always been found where they had been inserted in close crevices and folds occurring in the dry and discolored remains of the host plant, or in those of other plants present in the immediate vicinity. Balduf states, in correspondence, that moths which he had in confinement placed their eggs under the edges of loose bark of old elder stems, but adds that no other condition was provided. The writer has had moths do the same, but no preference was shown for this method of concealing the eggs.

Manner of Oviposition.

The female seems to locate a suitable place for her eggs entirely by the trial and error method. When her ovipositor enters a crevice narrow enough to offer the apparently necessary resistance she tarries long enough to deposit a mass of eggs before moving on to find another. In all the cases observed, the female turned her ovipositor about through a quarter turn in placing the eggs, the longitudinal axis of her body being parallel with the length of the crevice.

The eggs are pushed well down into the crevice or fold, to as great a depth as 3 mm., and are usually laid in more or less even masses of straight rows, as many as four rows being superimposed one upon the other. The eggs are securely cemented in place by a clear fluid provided by the moth. This cement appears to be chitinous in that it is unaffected by either hot or cold water, 70 per cent alcohol, xylene, ether or glacial acetic acid. A strong solution of sodium hydroxide failed to dissolve it in eight hours, although much of the chorion had been removed from the eggs Commercial sulphuric acid in the same length of time apparently had little effect on either the cement or the chorion of the eggs. On the other hand, hydrochloric acid attacked the cement but left the chorion of the eggs intact.

The approach of darkness stimulates the moths to activity and oviposition begins soon after. It was not learned how far into the night oviposition continued. Sudden exposure of the moths to bright light stopped all activity. By providing an artificial twilight it was possible to stimulate the moths to activity and to observe their behavior.

The duration of the period of oviposition for the fertilized females in confinement varied from one to four days. Two and one-half days was the average secured, and it would seem that this is more typical of the usual behavior of the insects than either extreme.

Daily and Total Egg Production.

Each female during her life deposited an average of 18+ egg masses which contained an average of 16+ eggs each. The largest number of egg masses deposited by one female during one day was 15, and the maximum total for one individual was 27. The smallest number of egg masses deposited by one individual during her entire life was 6. The number of eggs in the masses varied from 2 to 58.

The number of eggs deposited by a moth during one day and during her life varied greatly. Since all moths were fed from the beginning it is not known what effect a lack of food might have had on egg production. It has been found that food does affect the fecundity of some species of Lepidoptera, those having access to food being more productive. The effect of fertility on fecundity will be discussed under a separate heading.

The average daily egg production of the six females was 119. The minimum number of eggs deposited by any one female on one day was 44 and the maximum number was 281. The average number of eggs deposited by a moth during her life was 297 and the extremes of 148 and 453 were secured. This variability in number of eggs laid is by no means confined to this species of Lepidoptera.

Fertility.

It was learned that fertilized females may lay a few infertile eggs. These failed to change in color and soon collapsed. A few eggs were found that had changed color and then collapsed, indicating that death had followed soon after embryonic development had started.

Length of Incubation Period.

Achatodes zeæ spends approximately three-fourths of its life span within the chorion of the egg. Eggs laid during the latter part of July do not hatch until late in April or the first of May of the following year. Those laid in 1928 had hatched by May 1, 1929. Balduf states, in correspondence, that eggs which he had overwintered outside his window at Urbana, Ill., had hatched on April 25. The first eggs to be laid by a moth in confinement in Madison were deposited on July 20 and the last on August 2. When first laid, the eggs were a creamy white in color but began to darken by the third day, taking on a pinkish cast which deepened to a maroon, and within a week became a dark amber. Such a change indicates that embryonic development began very soon after the eggs were laid. Eggs dissected on November 15 disclosed that embryonic development had gone beyond the gastrula stage.

Habits of the Caterpillars.

With the coming of warm weather in the spring, the eggs hatch and the young caterpillars scatter in search of the tender shoots of the host plant, choosing to attack the more succulent portions. A newly hatched spindle worm displays considerable endurance and leads a solitary life from the beginning. As development progresses, the burrows are abandoned as they are outgrown or as the food supply becomes exhausted and new locations are sought.

The spindle worm is a gross feeder and in the later stages will mine out the hearts of the shoots until only a thin shell remains. With few exceptions the mines proceed upward from the point of entry. Large quantities of wet excrement are produced by the larva, only a portion of which is discharged from the entrance to its burrow. The bleeding of the continuously wounded plant tissues together with the excrement of the larva would soon make the burrow an undesirable habitation were it not that feeding is progressively upward and away. The caterpillars do very little silk spinning, but they do have this ability, as a larva collected on July 5 closed the opened end of its pupal chamber with a well formed silken web.

Length of Larval Life.

Larval life is approximately 60 days in length. The eggs begin hatching the latter part of April, and by the middle of May caterpillars can be found in a number of the earlier stages of development. A remarkable uniformity is shown in the completion of larval development when this unequal start is considered. Larval development in 1928 was noticeably retarded at the beginning when compared with that of 1929, although pupation took place about on time. On July 1, 1928, many pupæ were collected and only a few larvæ were found, these being taken in the cells constructed for pupation. On July 5, 1929, numerous pupæ were collected without a single larva being found.

Preparation for Pupation.

When larval development is nearing completion the spindle worms abandon the burrows in which they have been feeding and seek the dry and dead shoots of a former season's growth in which to construct their pupal chambers. An examination of such shoots often disclosed that they had been mined out by caterpillars in other seasons and that death probably resulted from the attacks of the caterpillars. Pupæ have also been collected from the dry stems of weeds that happened to be accessible; and where there was a dearth of suitable locations the caterpillars entered the pith exposed at the broken ends of old and woody stalks or stems lying prone on the ground. It was evident that the caterpillars preferred standing shoots when seeking a place in which to undergo transformation. The pupæ were usually found within two or three decimeters of the ground. In one instance a pupa was found nearly a meter above the ground and others have been found nearly as high.

There seems to be a definite limit to the hardness and thickness of the woody exterior of the stem through which the caterpillars will bore to reach the pith. Green shoots were found which displayed a number of attempts to bore into them. Each place had apparently been abandoned because of the resistance offered by the wood. Access to the pith of a dry shoot is often gained through an opening left by a former occupant. When the pith has been reached the caterpillar

mines through it for a considerable distance, more than two decimeters in one instance, upward if the stalk is standing, packing the dry frass behind it, then turns aside and cuts an exit for the moth. A thin layer of the outermost part of the stem is sometimes left to conceal the exit, or it may be closed by a few bits of frass carelessly placed. In rare instances a tympanum of silk had been used, but many times there seemed to have been no effort on the part of the caterpillar to close the exit. It may be that the pupa uses the protuberances on the cephalic end to clear the exit for the unimpeded issuance of the moth. The chrysalis is left in the pupal chamber with the issuance of the moth.

In attempting to account for the migration of the spindle worms from their feeding burrows in the green shoots to the dry stems in anticipation of pupation, the following factors were noted. The accumulation of wet excrement in the burrows, to which is added the moisture resulting from the bleeding of the wounded tissues of the host plant, provides an excellent medium for the development of numerous organisms of decay, and results in a place scarcely suitable for such an insect to undergo transformation. It was also noted that in instances where the shoots remained green, large knotty growths of parenchymatous cells were formed by the plant, apparently in an attempt to replace the tissue eaten away, and that often the exits left by the caterpillars had partially closed sometime before transformation had been completed. The spindle worm would be able to remove such an imprisoning obstruction, but the pupa would not and the moth would be trapped.

Length of Pupal Stage.

The length of the pupal stage was found to be quite variable. In 1928 the first moth issued on July 8 and the last on August 1. The first moths to issue in 1929 appeared on July 10. Eclosion reached its peak on July 18, then gradually fell off, the last moth appearing on August 3. In general, the pupal stage of *A. zeæ* can be said to occupy about 15 days.

Habits of the Moths.

The moths remain concealed during the day, secreting themselves in protected places. Their russet and gray coloring renders them inconspicuous, especially when hiding among the

discolored plant remains of an elder thicket. Activity begins with the coming of darkness. The moths are not readily induced to take flight during the day but usually drop to the ground and remain perfectly quiet. In fact it is possible to examine them then, turning them over and about in the hand at leisure with scarcely any activity being displayed. If they are disturbed during the dusk of evening they will either attempt to fly or will scuttle away into hiding. It was learned that they would feed on sugar solution. Whether or not food prolongs the life of the adult was not determined.

Longevity of the Adults.

Under the conditions outlined the males lived an average of 10 days, the fertile females 9 days, and the virgin females 10 days. A male holds the record for longevity having exceeded 14 days.

Oviposition Without Fertilization.

It was found that the oviposition of virgin females is greatly delayed. The preoviposition period of the six virgin females was $5\frac{1}{2}$ days as compared with the $2\frac{1}{2}$ day period of the six which were permitted to mate. Virgin females laid fewer eggs, an average of 140 eggs being obtained from them as compared to 297 from the fertilized females; and the egg masses deposited by them contained fewer eggs in the proportion of 12 to 16. The virgin females did not cement their eggs so securely in place as did the fertile females, nor were they so careful about placing them.

Associated Species.

Several times larvæ of *Papaipema sp.* were found in burrows that had been abandoned by spindle worms when they had gone in search of quarters for pupation. The stalk borers had apparently commenced feeding where the spindle worms had left off. Both the larvæ and pupæ of the elder leaf-tier, *Phlyctaenia tertialis* Gn.* were encountered while making these investigations. 'Early in June young larvæ of this species were found feeding on the unfolding leaves of the elder, and were again encountered during the first part of August in pupal

*Determined by Carl Heinrich.

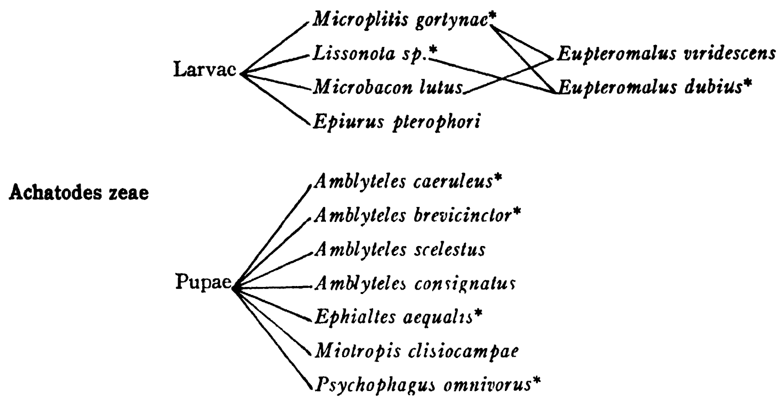
chambers which they had cut in the pith of the dead shoots. No evidence was found to indicate that they had been able to cut through the woody exterior of the stems, but had reached the pith through broken ends or through openings made by spindle worms. They had however, constructed their own pupal chambers in the pith. A common species of slug, *Limax sp.*, invaded the recently abandoned feeding burrows of the spindle worms in numbers

NATURAL ENEMIES.

An effort was made to gain some insight into the perils which threaten the safety of *Achatodes zeæ* during the course

CHART I.

KNOWN PARASITES OF *ACHATODES ZE1E* (HARRIS)



of its life. Data gathered would indicate that the chances for a full grown spindle worm to become a moth are less than one in three. The percentages given below are based on records covering a series of 172 specimens in 1928 and 124 in 1929. In 1928 about 28 per cent of the population was destroyed by Hymenopterous parasites while nearly a fifth of the population suffered from the predatory activities of birds. Hymenopterous parasites destroyed about 30 per cent of the population in 1929, while the activities of birds were not nearly so evident. Fungi and bacteria were certainly responsible for the death of many

*Found at Madison

individuals that failed to live beyond the pupal stage, although exact information on this is lacking. No Dipterous parasites were found attacking the species. Balduf's statement that "any parasites attacking the egg, larva, or pupa need to penetrate more or less woody tissue of the elder to reach the host" is not entirely in keeping with the writer's observations.

HYMENOPTERA*.

Microplitis gortynae Riley (Braconidæ).

Of the two species of Hymenoptera found destroying the larvæ of *A. zeæ* at Madison, *M. gortynæ* was the most important. Spindle worms parasitised by this species appear normal until pupation is imminent, when the parasite larvæ issue through the body wall of the host, death to the host being the result. This parasite was responsible for the destruction of nearly 10 per cent of the specimens of *A. zeæ* found. An average of 27 individuals issued from each caterpillar. The above figures agree with those obtained by Balduf for this parasite. Each parasite larva surrounded itself with a tough, ribbed, yellowish-white cocoon having a reddish cast. Balduf gives a detailed account of the issuance of these parasite larvæ from their host and of their cocoon spinning. He also states that the spindle worms are usually overcome and killed by the parasites in their original (feeding) burrows. With few exceptions the individuals attacked by this parasite at Madison were found in their pupal chambers The adult parasites did not emerge until late in May of the following year. Hawley (6) gives an account of the manner in which the caterpillars of *Gortyna immanis* Gn. were attacked by the adults of this parasite. His account suggests that the spindle worms may be attacked during their wanderings or that their burrows may be invaded by the parasite. *Microplitis gortynæ* is also a well known parasite of *Papaipema* larvæ.

About 30 per cent of *M. gortynæ* were parasitised by *Eupteromalus dubius* (Ashm.) (Pteromalidæ) in 1928. Specimens of this hyperparasite emerged during the middle of July of the

*The writer wishes to acknowledge his indebtedness to Messrs. Cushman, Gahan, and Morrison for their services in securing the determination of the Hymenoptera.

same year. *Eupteromalus dubius* obviously has more than one generation a year whereas the host is single brooded. The parsite cuts a neat cap from its cocoon in making an exit; but the hyperparasite cuts an irregular opening without consistency as to location. Cocoons of *M. gortynæ* secured in 1929 did not yield *E. dubius*.

Balduf found the closely related species *E. viridescens* (Walsh.) parasitising *M. gortynæ* in Illinois and Ohio and did not report *E. dubius*.

Lissonota sp., probably **brunnea** (Cress.) (Ichneumonidæ)

Two of the large brown cocoons of this parasite were found in the pupal chambers of *A. zeæ* in 1928. One of these bore the head capsule and skin of the host sticking to one end. Adults were secured from neither of these, one of them being parasitised by *E. dubius*. Twenty specimens of this hyperparasite issued from the cocoon on August 15. It is interesting to note that in this instance *E. dubius* is a multiple parasite whereas it is a solitary parasite of *M. gortynæ*. According to Balduf *E. viridescens* is a multiple parasite of *Microbracon lutus* (Prov.) (Braconidæ), a parasite of *A. zeæ* in Illinois and Ohio. Another of these cocoons was found in 1929, and on July 31 ten specimens of *E. dubius* issued from it.

Psychophagus omnivorus (Walk.) (Pteromalidæ)

This multiple parasite did not appear in 1928, but in 1929 it issued from 25 per cent of the pupæ collected. While collecting on July 14 a female was found in the act of ovipositing in a pupa. She had inserted her ovipositor through the conjunctiva between two segments of the abdomen. Both pupa and parasite were placed in a small bottle which was closed with a cotton stopper. On July 29 sixteen female specimens issued from the chrysalis. Only females issued from many of the chrysalids under observation while some yielded only males. An average of 20 females issued from those chrysalids on which definite data were secured, while 80 males issued from one.

Psychophagus omnivorus has also been recorded from pupæ of the apple-tree tent caterpillar, *Malacosoma americana* Fab.

Amblyteles caeruleus (Cress.) (Ichneumonidæ).

Over ten per cent of the parasitism of *A. zeæ* in 1928 was due to this species. This solitary parasite passes the winter in the larval stage within the chrysalis of the host. Specimens overwintered outside by the writer, emerged on June 1 and 5. Adults confined in a cage with shoots containing spindle worms were very alert and shy, dodging for cover with the least provocation. On several occasions dead and mangled spindle worms were found on the bottom of the cage, and although the parasites were not observed to do so, it would appear that they had killed the caterpillars. The experiment was interrupted without observing the oviposition of the parasites. This species has but one generation a year, which like that of *M. gortynæ*, is nicely adjusted to the cycle of the host. Balduf also reports this species as a parasite of *A. zeæ* in Illinois.

Amblyteles brevicinctor (Say).

This solitary parasite is represented by one specimen that issued from a chrysalis of *A. zeæ* on July 14, 1929. Since this chrysalis was of the 1929, generation it is obvious that the parasite has more than one generation a year. This species has also been secured from pupae of the European corn borer, *Pyrausta nubilalis* Hubn.

In addition to the *Amblyteles* recorded above, Balduf found *A. scelestus* (Cress.) parasitising *A. zeæ* in Ohio and *A. consignatus* (Cress.) attacking it in Illinois.

Ephialtes aequalis (Prov.) (Ichneumonidæ).

Ephialtes aequalis is another solitary parasite that was secured for the first time in 1929. Two specimens issued from chrysalids of *A. zeæ* on July 25 and 29 respectively. These pupæ were of the 1929 generation so the parasite has more than one generation a year. This species is a well known enemy of the codling moth, *Carpocapsa pomonella* L., and has been recorded from a great variety of Lepidopterous hosts.

In addition to the species that have been mentioned, Balduf secured specimens of the following parasites from *A. zeæ* in Ohio: *Epiurus pterophori* (Ashm.) (Ichneumonidæ) and *Miotropis clisiocampæ* Ashm. (Eulophidæ).

DIPTERA.

Dipterous parasites were not encountered during the course of these investigations at Madison. Balduf reports the interesting habits of *Aphiochaeta aletiæ* (Coms.), a Phorid which he found preying on spindle worms that were in a diseased condition. He reports that the species is a scavenger, the maggots appearing to habitually feed internally in the caterpillars, utilizing the anal or perhaps the oral opening as a place for entrance.

BIRDS.

It has been a common experience to find pupal chambers of *A. zeæ* that had been opened and robbed of their occupants by some species of woodpecker. In 1928 evidence was obtained which indicated that nearly a fifth of the population had suffered from the predatory activities of birds. No indications were found that birds had taken larvæ from the green shoots in which they feed. The activities of birds were not nearly so evident in 1929.

DESCRIPTIONS.

The spindle worm is the most easily recognized of all the Noctuid borers. Taxonomists have found that the larvæ of *A. zeæ* present morphological characters of unusual specific value. A detailed description of the sixth instar larva has been prepared and remarks on other instars relate to that.

The Egg.

The egg of *Achatodes zeæ* is circular in cross section, flattened at both poles, creamy white when first deposited, by the third day it is darker, having taken on a reddish cast which, within a week, deepens to a dark amber, and just before hatching becomes even darker. Polar diameter .33 mm., equatorial diameter .66 mm. Chorion of equatorial area sculptured with shallow somewhat uneven pits that are faintly hexagonal in outline; that of the polar areas smooth, unmarked except for the micropyle. The eggs are usually fairly well covered with a translucent cement produced by the moth for making them secure.

The Larva.

First instar.—Body white, about 3 mm. long. Head about .3 mm. broad. Setæ proportionately long. Head, cervical and anal shields brownish; spines on anal shield not evident; spiracles circular; tubercles brownish, III a of abdomen not evident.

Second instar.—Body white, about 6 mm. long. Head about .6 mm. wide. Setæ proportionately long. Head, cervical, and anal shields brownish-black; anal shield rugose, spines scarcely evident; spiracles circular; tubercles brownish, III a of abdomen not evident.

Third instar.—Body white, about 12 mm. long. Head about 1.15 mm. wide. Setæ proportionately shorter. Spines on anal shield well developed; spiracles ovate; tubercles with more impigmentation; III a of abdomen evident.

Fourth instar.—Body white, about 20 mm long. Head about 1.7 mm. wide. Appearance very much that of sixth instar larva.

Fifth instar.—Body white to yellowish white, about 25 27 mm long. Head about 2.15 mm wide. Appearance that of sixth instar larva.

*Sixth instar larva.**—Head 2.5 to 2.7 mm. broad. Body averaging 35 mm. in length and 4 2 mm. in width, cylindrical, of nearly uniform width throughout, segments AIII, AIV, AV, and AVI, being a little the broadest; posterior extremity spined; skin smooth, general color white to yellowish-white; tubercles prominent, elevated, unisetiferous, glossy-blackish; those of segment AIII circular except where noted: Tubercles II elliptical and about 1½ times as far apart as tubercles I, III dorso-cephalad of spiracles, IIIa cephalad ot spiracles, IV caudad and a little ventrad of spiracles, V elliptical, ventrad and a little cephalad of spiracles, VI dorsad and caudad of VII, VII partially encircle prolegs, and VIII very small, located one on the inside of each proleg; tubercles III and IIIa on AVIII usually fused, and IV is farther ventrad on AVIII than on AVII; those of AIX are mostly fused and contiguous with the anal plate.

Head, cervical and anal shields are strongly chitinized, uniform glossy black; adfrontal sutures translucent, terminating in the occipital foramen; spinneret conical, exceeding the basal segment of the labial palpus, tapering to a truncated tip; anal shield rugose, bearing on its caudal margin a row of usually six large upturned spines; rims of spiracles jet black, central portions sooty black.

Legs blackish, bases of claws broadly rounded. Prolegs unmarked except for impigmentation around tubercles VII, about 27 chrochets on each of first pair

Pupa.

The pupa is russet brown in color, about 17-21 mm. in length and 4-5 mm. in width; maxillary palpi not present; front drawn out anteriorly into two slightly diverging prominent processes that are coarsely rugose; clypeus conspicuously protruding ventrad, rugose; maxillæ visible to near tips of mesothoracic legs, a little farther caudad than spiracle on fourth abdominal segment; antennæ visible almost as far; anterior thirds of abdominal segments 4, 5, 6 and 7 sculptured with numerous, irregularly placed, round punctures; the third sculptured with the same anteriorly on the dorsum; spiracles elongate, oval, directed laterally, those of segments 2 and 3 bounded dorsally with

*See Ellis for figure of sixth instar larva.

numerous coencentric sinuaté ridges, cremaster well developed with four stout divergent spines directed dorsad; posterior surface of cremaster coarsely rugose, the rugosity seeming to originate as diverging ridges radiating from the caudal end of the anal slit; four stout accessory spinules anterior to cremaster directed caudad.

*Adult.**

Forewing russet, mottled with gray, a bright orange spot at apex, another near base on inner margin, a third smaller near anal angle; bands obscured and wanting, terminal band brownish fuscus, transverse posterior band indicated by a double row of fuscus markings on veins, median and anterior bands suggested by grayish fuscus mottlings. Hind wings yellowish gray. Antennæ yellowish. Palpi grayish fuscus. Face ferruginous to yellowish. Vertex orange. Thorax yellowish on mid-dorsum. Beneath yellowish gray, segments of tarsi outlined by pale yellowish.

Male genitalia: Uncus represented by a stout straight spine directed caudad and ventrad; gnathos nearly as long as uncus; socii short, diverging somewhat, capitate; cucullus and sacculus of harpes well differentiated, cucullus about half as wide as sacculus, neck about one-third as wide as cucullus; costal hook short, stout, directed toward cucullus; aedoeagus without cornutii.

Alar expanse: Male about 30 mm , female about 33 mm

The writer is indebted to Prof. H. F. Wilson of the University of Wisconsin for the courtesy of reading the manuscript of this paper.

SUMMARY.

1. The spindle worm, *Achatodes zeæ* (Harris), has been under observation at Madison, Wisconsin since the spring of 1927.

2. It is believed that the range of the species will prove to be coextensive with that of its natural host plant, *Sambucus canadensis* L.

3. Data gathered would indicate that while *A. zeæ* may be considered a potential pest of certain crops in some localities, it rarely attacks these in its natural environment.

4. Detailed observations of the activities of the species under natural conditions were made, and were supplemented by studies of specimens in confinement.

5. *Achatodes zeæ* has but one generation a year, and shows a nicety of adjustment to the seasonal development of the host plant.

*Holland (7, Plate XXVI) figures the moth in color.

6. The overwintering eggs hatch with the coming of warm weather and the young caterpillars seek the succulent shoots of the elder.

7. Toward the end of June larval development is nearing completion and the caterpillars abandon their feeding burrows to seek quarters for pupation in the dry dead shoots of a former season's growth.

8. Eclosion reaches its optimum by the middle of July. Oviposition begins within a few days after the emergence of the moth.

9. The eggs are inserted in close crevices and folds that occur in the dead and discolored remains of the host plant or in those of other plants in the immediate vicinity.

10. Data on the longevity, preoviposition and oviposition of the adults are given.

11. Natural enemies found attacking *A. zeæ* at Madison are: *Microplitis gortynæ* Riley, *Lissonota sp.*, probably *brunnea* (Cress.), *Psychophagus omnivorous* (Walk.), *Amblyteles caeruleus* (Cress.), *A. brevicinctor* (Say), and *Ephialtes aequalis* (Prov.) (Hymenoptera); and birds.

12. Biological notes on the Hymenoptera are included.

13. Quantative data obtained indicate that the chances for a fully developed spindle worm to become a moth are somewhat less than one in three.

14. Descriptions of the various stages of *A. zeæ* have been written.

LITERATURE CITED.

(1) **Balduf, W. V.** 1929. Bionomic Notes on Some Parasites of Achatodes zeae (Harris) (Noctuidae, Lep.) and Phlyctaenia tertialis (Guen.) (Pyralidae, Lep.). Ohio Jl. of Sci. XXIX, pp. 218–230, Columbus.

(2) **Ellis, W. O.** 1925. Some Lepidopterous Larvae Resembling the European Corn Borer. Jl. Agric. Res. XXX, pp. 777–792, 2 pls. Washington, D. C.

(3) **Entomology.** 1927–1928. Ann. Rep. Iowa Agric. Exp. Sta., p. 60. Ames.

(4) **Felt, E. P.** 1923. Thirty-fifth Report of the State Entomologist, 1921. New York State Mus. Bull., Nos. 247–248, pp. 74–75. Albany.

(5) **Harris, T. W.** 1862. Insects Injurious to Vegetation. Flint Edition, pp. 438–439.

(6) **Hawley, I. M.** 1918. Insects Injurious to the Hop in New York. Cornell University Mem. 15, p. 168. Ithaca.

(7) **Holland, W. J.** 1915. The Moth Book. Doubleday, Page & Company, Garden City, N. Y.

(8) **Smith, M. R.** 1920. An Insect Supposed to Breed in Corn. Jl. Econ. Ent. XIII, p. 493. Concord, N. H.

THE BIOLOGY OF THE BOOK-LOUSE, TROCTES DIVINATORIA, MULL*

O. W. ROSEWALL,
Louisiana State University.

The book-louse, a more or less cosmopolitan insect, was definitely brought to the attention of the author several years ago by the finding of heavy infestations in corn meal. Samples of this infested meal were placed in small wide-mouthed glass stoppered jars. After a period of six months or so the jars were fairly teeming with book-lice in various stages of growth. A careful study of the specimens proved that they were all of one species, *Troctes divinatoria* Mull. This source of material has furnished specimens for the life history studies considered in this paper, and the paper is written with special emphasis on the use of the book-louse in classes in Entomology.

All literature perused by the author has not brought forth a life history study of the book-louse. All accounts deal principally with reports of its presence, classification, economic importance, and control measures. References to life history of any of the Psocoptera are in regard to the winged forms, though H. A. Hagen reports having watched a large colony of book-lice in confinement in order to definitely prove that the apterous condition was constant.

The use of the Book-louse in life history studies is very satisfactory. Each student is given a mature specimen from which to obtain eggs and the following equipment must be available:

A large supply of drop-culture slides; those of matte finish with bottom of cell smooth and not polished are the best.
Trays to hold slides which are of a size easy to handle.
Cover slips, size 22 mm.
Vaseline.
Corn meal; yellow seems to be the most satisfactory as food.

The book-louse is placed in the cell of a drop-culture slide with a few grains of corn meal. Too much corn meal will make it almost impossible for a beginner to find the eggs.

*Identification verified by A. N. Caudell, U. S. Bureau of Entomology.

The cell is then covered with a 22 mm. cover-slip held in position by a trace of vaseline. As the eggs appear they are placed in separate slides and properly labeled. The eggs usually adhere to the point of a needle when touched, so it is an easy matter to transfer them. The work is best handled indoors, as in the case of nearly all life history work, in a room of fairly constant temperature.

Sometimes the work is carried on for quite a while before the student inquires as to where the males are.

Parthenogenesis: After several years of observation on the life history of the book-louse the author reached the conclusion that parthenogenesis occurs in the book-louse, which fact

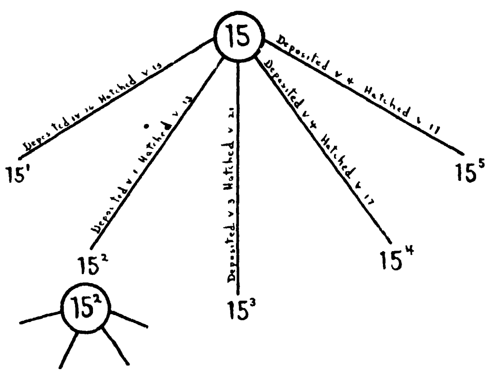


FIG. 1. Diagram for plotting life histories of the book-louse.

makes it more interesting for use in life history work by the student. It also makes the routine work easier. So far the author has never found a male book-louse.

In the experiment the original female, with which the experiment begins, is given a number as shown below. Each radiating line represents an egg deposited by the female and is given a number which is placed at the termination of the line. The time of deposition and hatching may be recorded along the line.

Nymphs 15^1, 15^2, 15^3, etc., may be carried respectively on the same plan.

**Eggs:* The white, oval-shaped eggs are usually placed among or under the meal particles and are rather difficult to

*A technical description of the egg and nymphal stages will appear in a separate paper.

find. The rate of deposition changes with the weather conditions.

Nymph: The nymphs upon hatching are pure white and at this stage, when motionless, are as difficult to find as the eggs. After each molt the nymph becomes darker in color and the adult is of a light brown color, though the degree of brownness varies a great deal. Typically there are three molts requiring a period of about thirty days.

A summary of the tabulated data of life history studies carried on during the months of October to January inclusive, with temperature ranging from 50° to 87° F., is as follows:

TABULATION OF RESULTS
(Time in Days).

No. of specimen	1	2	3	4	5	6	*7	*8	*9	*10	Av.
Preoviposition Period	46	51	36	46	44	51	54	49	42	31	45
No eggs deposited ..	7	30	28	14	9	9	31	44	36	12	20
Av Incubation Period	19	20	20	22	27	25	21	23	24	11	21
Life Cycle	111	130	94	93	117	116					110
Postoviposition Period	24	9	1	4	16	1					9

*Denotes that adults are still alive

For comparison with the above averages, we find that averages obtained during the months of June to August inclusive, with temperature ranging from 60° to 95° F. were as follows:

Average Incubation Period	6 91 days
Average Number Eggs Deposited	57
Average Life Cycle	24 38 days

The above averages, in comparing the summer months with the winter months, show clearly the effect of temperature on the length of life of the book-louse.

During the past year, one female which lived from June 27 to October 27, deposited a total of 98 eggs.

JAMES WALKER McCOLLOCH.

On November 11, 1929, James Walker McColloch, of the Department of Entomology of the Kansas State Agricultural College, died at Manhattan, Kansas.

Professor McColloch was born at Anthony, Kansas, April 14, 1889. While still an undergraduate student at the Kansas State Agricultural College he began his entomological work on an appointment as special field agent. His investigations, begun at this time (1910) on such major pests of field crops as the corn earworm, Hessian fly and chinch bug, eventually led to wide recognition of his abilities as a research worker. As an example of what his ability and sound judgment meant to other investigators in his field, a noted State Entomologist from one of the eastern states recently made the statement to the writer that "whenever a perplexing problem confronts me upon which I seek advice from others I write to 'Mac' and can be assured of sound help in his reply."

Upon completion of his bachelor's work in 1912, he was appointed assistant entomologist of the Kansas Agricultural Experiment Station and his work on the control of chinch bug and Hessian fly, dust sprays for corn earworm and the discovery of the chinch bug egg parasite led to his promotion in 1918 to Associate Professor of Entomology and Associate Entomologist of the Kansas Agricultural Experiment Station. His field of endeavor had expanded to include work on soil-inhabiting insects—especially wireworms and white grubs, insect ecology, the resistance of plants to insect injury, and at the time of his death he was carrying on extensive studies of soil insecticides. Along with these labors, he found time to do some graduate work and in 1923 received the degree of Master of Science. His executive ability was amply demonstrated during a two years' absence of the head of his department when he served as Acting Head of the Department and State Entomologist, a service which led to his appointment, in 1925, to the rank of Full Professor.

His many publications indicate the wide variety of interest he had in his chosen field. His scientific papers, circulars and bulletins are real contributions to entomology and many are widely quoted. Some of his outstanding papers are those on the chinch bug egg parasite, life history studies of the false wireworms, resistance of wheat to Hessian fly injury and his bulletins and circulars on the chinch bug and Hessian fly. His Kansas bulletin on the Hessian fly is the most comprehensive work on the subject that we have had in recent years. He loved to write and his critical ability led to editorial duties. At the time of his death he was Editor of the Bulletin of the Kansas Entomological Society. He was sectional editor for Biological Abstracts; was serving

on the editorial committee of the Kansas Agricultural Experiment Station and a member of the advisory committee of the Journal of Economic Entomology. In addition to his writing ability, he was a forceful speaker, one of the few research workers who could get his ideas across to farmers.

He was an ardent worker in the American Association for the Advancement of Science, American Association of Economic Entomologists, Entomological Society of America, Kansas Entomological Society, American Miscroscopical Society, Ecological Society of America and the Kansas Academy of Science. He was a member of Sigma Xi, Phi Kappa Phi, Gamma Sigma Delta, and Alpha Zeta. He took an active part in the conference of the North Central States Entomologists and the Rocky Mountain Entomological Conference. In all of these he demonstrated by his activities his earnest effort to promote the utmost co-operation among entomological investigators. The loss of his stimulating influence, friendship and helpful advice is inestimable and American economic entomology will miss him keenly.

—WM. P. HAYES

PROCEEDINGS OF THE TWENTY-FOURTH ANNUAL MEETING.

Des Moines, Iowa, December 28th to 30th, 1929.

The Twenty-fourth Annual Meeting of the Entomological Society of America was held at Des Moines, Iowa, December 28, 29 and 30, 1929. The program included an unusual variety of topics and many valuable contributions to our knowledge of insects. The attendance ranged from 75 to 150, with a total approximate attendance of 215 entomologists.

The Annual Public Address was delivered by Dr Wm. M. Mann, and was attended by 300 entomologists and others interested. The symposium was also very successful. The topic, "Important Contributions which America has made of the Study of Insects," was exceptionally well handled by C. E. Mickel, D. M. DeLong, W. P. Hayes, E. F. Phillips, S. A. Graham and Arthur Gibson.

Opening Session, Saturday Morning, December 28th.

The Society was called to order at 10:15 A. M. by President Brues, in the Ball Room of the Savery Hotel, Des Moines, Iowa. Attendance, 150. The following papers were presented:[1]

1 The Food of Insects Viewed from the Biological and Human Standpoint. C. T. BRUES, Bussey Institution

2 Another Season's Trap-lighting of Leafhoppers. PAUL B. LAWSON, University of Kansas

3 Dragonfly Collecting in China. J. G. NEEDHAM, Cornell University

4 *On the Isolation, Cultivation and Classification of the so-called "Symbiont" or "Rickettsia" of *Periplaneta americana*. R. W. GLASER, Rockefeller Institute

5 Key to Known Pupae of Genus Calendra with Host Plant and Distribution Notes. A. F. SATTERTHWAIT, U. S. Bureau of Entomology.

6 An Obscure Syrphid Differentiated by its Larval Characteristics. C. L. METCALF, University of Illinois

7 *Two South American Palm Bruchids. E. A. BLACK and R. T. COTTON, U. S. Bureau of Entomology

8 *Leaf Miners of Aquilegia, with Descriptions of New Species. S. W. FROST, Arendtsville, Pa

9 *Notes on Utah Aphididae. GEO. F. KNOWLTON, Utah Agricultural Experiment Station

10 *Biology of *Frankliniella fusca* Hinds (Thysanoptera). C. O. EDDY and E. M. LIVINGSTONE, Clemson College

11 *The Biology of the Book louse. O. W. ROSEWALL, Louisiana State University.

12 Contributions to a Knowledge of the Spindle Worm, *Achatodes zeae* Harris. E. P. BREAKEY, Wisconsin Department of Agriculture

The following committees were appointed by President Brues:

Nominating Committee—J. G. NEEDHAM, Chairman; ARTHUR GIBSON, G. A. DEAN

Auditing Committee—C. R. CROSBY, Chairman, W. S. HAYES, C. E. MICKEL.

Resolutions Committee—E. D. BALL, Chairman; C. L. METCALF, C. P. GILLETTE.

Special Committee on Nomenclature. THEO. D. A. COCKERELL, Chairman; J. M. SWAINE, H. H. KNIGHT.

---

[1]Papers indicated by an asterisk (*) not read

Second Session, Saturday Afternoon, December 28th.

The Society was called to order at 1:45 P. M. Attendance, 125. The following symposium was presented:

IMPORTANT CONTRIBUTIONS WHICH AMERICA HAS MADE OF THE STUDY OF INSECTS.

1. Taxonomic .... C. E. MICKEL
2. Biological .... D. M. DELONG
3. Morphological .... W. P. HAYES
4. Physiological .... E. F. PHILLIPS
5. Ecological .... S. A. GRAHAM
6. Economic .... ARTHUR GIBSON

The following paper was presented:

13. Nesting Habits and Parasitic Relationships of Wild Bees. G. P. CUSTER, State University of Iowa. The paper was followed by two reels of moving pictures.

Third Session, Sunday, December 29th.

Members of the Society went to Ames, where they inspected the entomological facilities of the Iowa State College and listened to an interesting talk by Prof. Herbert Osborn on entomologists of the middle west.

Fourth Session, Monday Morning, December 30th.

The Society was called to order at 9:30 A. M., in the Assembly Room of the Savery Hotel. Attendance, 100.

The following papers were presented:

14. A Contribution of the Knowledge of the Life History of *Bremus americanorum* (Fabr.) (Hymenoptera). T. H. FRISON, University of Illinois.
15. The Biotic Constants of Insects. R. N. CHAPMAN, University of Minnesota.
16. An Analysis of Metamorphosis in Insects. C. H. KENNEDY, Ohio State University.
17. *Nutrition of Certain Wood-Boring Insects. NELLIE M. PAYNE, University of Pennsylvania.
18. Dormancy in *Reduvius personatus* (Linnaeus). P. A. READIO, University of Kansas.
19. Insect Excretion - Studies on the Malpighian Tubules. R. A. MUTTKOWSKI, University of Detroit.
20. The Hypodermal Glands of the Black Scale, *Saissetia oleæ* (Bernard) WM. S. MARSHALL, University of Wisconsin.
21. The Postembryonic Development of the Antennæ of Certain Paurometabolous Insects. F. L. CAMPBELL, U. S. Bureau of Entomology.
22. Tracheal System of the Larva of the Rice Water Weevil (*Lissorhoptrus simplex*). DWIGHT ISELY and H. H. SCHWARDT.
23. Tarsal Claws of Noctuid Larvæ. J. H. HAWKINS, Maine Agricultural Experiment Station.
24. The Beginning Course in Entomology. STANLEY B. FREEBORN, University of California.
25. Why do we Study Insects? E. P. FELT, Bartlett Research Laboratory.

Fifth Session, Monday Afternoon, December 30th.

The Society was called to order at 1:45 P. M., in the Assembly Room of the Savery Hotel. Attendance, 75.

The following papers were presented:

26. Early Work and Workers in American Hemipterology. HERBERT OSBORN, Ohio State University.
27. Entomology Around the World. T. D. A. COCKERELL, University of Colorado.
28. Rearing and Contact Insecticide Tests on Houseflies. GEO. L. HOCKENYOS, University of Illinois.
29. Some Erythroneura of the Obliqua Group (Homoptera-Cicadellidae). R. H. BEAMER, University of Kansas.
30. An Unusual Nest of Vespa. H. B HUNGERFORD, University of Kansas.
31. *Here and There in European Museums. H. B. HUNGERFORD, University of Kansas.

The Annual Business Meeting followed the reading of papers. as follows:

REPORT OF THE SECRETARY.

Previous to July 1, 1929, the following, having been duly nominated and recommended, were elected members of the Society by mail ballot of the Executive Committee:

H. C. ATWELL, 101 Court House, Portland, Oregon.
CLINTON J. BUSHEY, Olivet College, Olivet, Illinois.
RODNEY CECIL, Agricultural Experiment Station. Geneva, N. Y.
S. M. CENDANA, Agricultural College, Laguna, P. I.
DONALD DELEON, Forest Insect Field Station, Coeur d'Alene, Idaho.
MISS IRENE D. DOBROSKY, 1086 N. Broadway, Yonkers, N. Y.
DELBERT L. MOODY, Department of Zoology, Ames, Iowa.
JEAN PIATT, 344 Northern Ave., Indianapolis, Ind.
S. ALBERT SHAW, Hampton, N. H.
FREDERIK J SPRUIJT, P. O. Box 277, Sumner, Wash.
NOBUYOSHI TOZAWA, Komatsubora-cho 62, Kitaku, Osaka, Japan.
C. W. WURSTER, 15 West Eleventh St., New York, N. Y

With the approval of the Executive Committee, Dr. Wm. M. Mann was invited to give the annual address of the Society at the Des Moines meeting. It was also decided to hold a symposium on the subject, "Important Contributions which America has made of the Study of Insects."

Dr. C H. Richardson kindly consented to act as chairman of the Committee on Arrangements for the Des Moines meeting.

The Executive Committee met at 5:00 P. M., December 28, in Room 402, Savery Hotel, the following members being present: C. T. BRUES, H. B. HUNGERFORD, C. H. KENNEDY, W. A. RILEY and J. J. DAVIS; also the following appointed to act for those members not present: WM. S. MARSHALL, C. L. METCALF, ARTHUR GIBSON, G. A. DEAN and F. C. BISHOPP.

The following were elected to membership:

L. D. ANDERSON, 1621 Edgehill Road, Lawrence, Kansas.
O. S BARE, 1535 N. Thirty-second St., Lincoln, Nebraska.
WM. DELLES BEDARD, 334 Clairmonte Ave., Syracuse, N. Y.
LUCIEN BERLAND, sous-directeur du Laboratoire d'entomologie au Museum d'Histoire Naturelle, 45 rue de Buffon, Paris Ve, France.
MARION W. BOESEL, Zoology Department, Miami University, Oxford, Ohio.
MYLOS F. BOWEN, 441 N. Fifth, East, Logan, Utah.
TOM A. BRINDLEY, Science Bldg., Iowa State College, Ames, Iowa.
FRED D BUTCHER, Extension Service, Iowa Agricultural College, Ames, Iowa.
LOUIS CERNY, 1001 West Hills Pky., Lawrence, Kansas.
JOHN F. CHRISTENSEN, Wellsville, Utah.
DONALD L. COLLINS, 144 Pulteney St., Geneva, N. Y.
JAMES G. CONKLIN, Department of Entomology, O. S. U., Columbus, Ohio.
CLARENCE PHILIPS CUSTER, University Hospitals, Iowa City, Iowa.

Merrill M. Darley, 473 Fourth Ave., Salt Lake City, Utah.
E. Hoyt DeKleine, 201 1 Tilden Gardens, 3000 Tilden St., N. W., Washington, D. C.
Howard Dorst, 925 Indiana St., Lawrence, Kansas.
Craig W. Eagleson, B. & Z. Bldg., Ohio State University, Columbus, Ohio.
John Harwood Evans, 502 West Illinois St., Urbana, Ill.
Neal E. Evans, 1201 Tennessee St., Lawrence, Kansas.
Howard Emerson Guthrie, 2644 Lincolnway, Ames, Iowa.
Kenneth A. Haines, Department of Entomology, Ohio State University, Columbus, Ohio.
F. H. Harries, 473 Fourth Ave., Salt Lake City, Utah.
Nicholas W. Hatfield, 3302 E. Fall Creek Blvd., Indianapolis, Ind.
Paul E. Hering, Department of Biology, Rensellaer Poly. Institute, Troy, N. Y.
Edgar Herr, Ohio Agricultural Experiment Station, Oak Harbor, Ohio.
Wm. A. Hiestand, Biology Bldg., Wisconsin University, Madison, Wis.
Alexander C. Hodson, Zoology Department, University of Minnesota, Minneapolis, Minn.
Elmer C. Hodson, 48 Sherwood St., Roslindale, Mass.
Clarence Hoffman, 1133 Rhode Island St., Lawrence, Kansas.
Edward Walley Jones, Department of Entomology, University Farm, St. Paul, Minn.
Chester B. Keck, Box 491, Orlando, Fla.
Earl Lott, A. & M. College, Miss.
Annie Laurie McClanahan, Box 184, A. & M. College, Miss.
H. Elliott McClure, 925 W. Wood St., Decatur, Ill.
Edw. R. McGovran, Department of Entomology, Iowa State College, Ames, Iowa.
William D. McIlroy, 192 Prospect Ave., Ingram, Pa.
Harlan B. Mills, Science Bldg., Ames, Iowa.
Dudley Moulton, 149 California St., San Francisco, Calif.
Paul Oman, 925 Indiana St., Lawrence, Kansas.
Andre Audant, Department of Entomology, Kansas State Agriculture College, Manhattan, Kansas.
Harold Peters, 1709 Louisiana St., Lawrence, Kansas.
Arthur M. Phillips, Box 2080, Orlando, Fla.
Griffin L. Phillips, Baldwyn, Miss.
Lucius B. Reed, Box 415, Picayune, Miss.
Henry H. Richardson, Science Bldg., Iowa State College, Ames, Iowa.
Merrill F. Riley, 2535 B East Manoa Rd., Honolulu, Hawaii.
Kay Sakimura Greenwood, Utah.
Carl Theodor Schmidt, Division of Entomology, University Farm, St. Paul. Minn.
Herman Schroeder, 1336 Vermont St., Lawrence, Kansas.
Laurel Seely, 1743 Louisiana St., Lawrence, Kansas.
Gilbert Shaw, 808 Alabama St., Lawrence, Kansas.
Wesley E. Shull, 121 Almon St., Moscow, Idaho.
Perez Simmons, 712 Elizabeth St., Fresno, Calif.
Archie Norman Solberg, 1307 Thirteenth St., North, Fargo, N. Dak.
Henry A. Stabe, Department of Zoology, Louisiana State University, Baton Rouge, La.
John Benjamin Steinweden, 149 California St., R. 420, San Francisco, Calif.
L. LaGrande Stirland, Providence, Utah.
Edwin Swope, 730 Kentucky St., Lawrence, Kansas.
Raymond Leech Taylor, Maine Forest Service, Bar Harbor, Maine
James R. Thomson, Box 445, Fort Valley, Ga.
Y. H. Tsou, Bureau of Entomology, Hangchow, China.
Leonard D. Tuthill, 246 E. Thirteenth St., Baxter Springs, Kansas.
Henry Thomas Vanderford, A. & M. College, Miss.
Robert Emerson Wall, 1506 Raymond Ave., St. Paul, Minn.
R. M. White, Treesbank, Manitoba, Canada.
Donald Alden Wilbur, Entomology Department, Kansas State Agricultural College, Manhattan, Kansas.

GEORGE VAN WILBY, North Dakota Agricultural College, Fargo, N. Dak.
HOMER C. WILL, Dept. of Zoology, University of Pittsburgh, Pittsburgh, Pa.

Total new members, 80.

The following members have died during the year:

EDWIN E. CALDER, January, 1929.
WALTER M GIFFARD, June 30, 1929.
FRANK M. GIBSON, September 24, 1929.
J. W. MCCOLLOCH, November 11, 1929.

The following members have resigned during the year:

Lloyd Ackerman, W. D. Edmondson, H. L. Fackler, W. H Goodwin, Wm. A. Haren. Marshall Hertig, S. Arthur Johnson, Wm. Middleton E. Mortensen, E. R. Sasscer, Nina G. Spaulding, Geo. W. Still, B. W. Wells, and J. E. Williams.

The following members were elected to fellowship:

C. F. Adams, A. C Baker, A. C. Boving, P. W. Claassen, C. R. Crosby, T. H. Frison, W. P. Hayes, W. B. Herms, E. F. Phillips, and S. A. Rohwer.

J. R. de la Torre Bueno, on payment of $50.00, was transferred to life membership.

Moved and seconded that the selection of members of the Editorial Board of Annals to succeed R. W Doane, J. A. G. Rehn and H. E. Ewing, be left in the hands of C. H. Kennedy and Herbert Osborn. Carried. Members selected are W. B. Herms, R. E. Snodgrass and P. P. Calvert.

Moved and seconded that H. E. Ewing and P. B. Lawson be elected to membership on the Thomas Say Foundation Committee to succeed J. C. Bradley and Arthur Gibson. Motion carried.

Moved and seconded that, in the case of nomination of foreign members, the advance payment of dues be waived, provided that membership in the Society be withheld until the payment of such dues. Motion carried.

Moved, seconded and carried that a memorial of the late J. W. McColloch be published in the ANNALS.

Voted to recommend to the Society that it support the Zoological Record for the coming year to the extent of $25.00. To this amount, Theo D A. Cockerell added $5 00, making a total of $30.00.

Voted to accept the invitation of the National Research Council to membership and representation in the Division of Biology and Agriculture of the Council.

Arthur Gibson was asked to present to the Fourth Empire Imperial Bureau Conference, greetings from the Society.

A communication from the National Committee on Calendar Simplification was laid on the table without action.

The Executive Committee adjourned at 7:00 P. M.

Respectfully submitted,

J. J. DAVIS, *Secretary.*

On motion the Secretary's Report was accepted.

REPORT OF THE TREASURER.

CURRENT FUNDS.

RECEIPTS.

Balance, December 28, 1928 (See ANNALS, XXII, p. 150)	$2,050.45
From Annual Dues of Members to December 19, 1929	2,109.97
From Managing Editor of the ANNALS	1,625.69
One Life Membership	50 00
Interest on Savings Account, July 1, 1928, to July 1, 1929	124.41
Interest on Liberty Bonds	15.48
Total	$5,976.00

EXPENDITURES.

Exchange on Canadian Checks (Check 72)	$ 85
Stamps (Checks 73, 75, 77, 90)	25 25
Stamped Envelopes (Checks 81, 84, 88)	65 56
Lafayette Printing Co., 1928 Programs (Check 74)	33 00
Lafayette Printing Co., Letterheads, Blanks, 1929 Programs, etc. (Checks 76 and 93)	70 75
Spahr & Glenn Co., Printing Annals for December, 1928, March, June and September, 1929 (Checks 78, 80, 85, 91)	2,999 95
Clerical Services (Checks 79, 82, 83, 87, 89, 92)	71 80
C. H. Kennedy, Etching Paid by S. W. Frost (Check 86)	3 62
Transferred to Permanent Fund for One Life Membership	50 00
Interest Transferred to Permanent Fund	139 89
J. J. Davis, Cash Payments per Attached List (Check 94)	5 31
Total	$3,465 98
Balance, Cash on Hand, Purdue State Bank, December 10, 1929	2,510 02
	$5,976 00

LIABILITIES.

The Society owes the publishers for the December, 1929, ANNALS and a few miscellaneous expenses, and $1,086.00 of the above cash receipts are 1930 dues.

PERMANENT FUND.

Liberty Bonds (ANNALS XXII, p. 150)	$ 350 00
In Purdue State Bank (ANNALS XXII, p. 150)	1,850 00
One Life Membership (J. R. de la Torre Bueno)	50 00
Interest on Savings	139 89
Total	$2,389 89

RESOURCES.

Liberty Bonds	$ 350 00
Savings Account, Purdue State Bank	3,486 96
Balance in Checking Account, Purdue State Bank	1,062 95
Total	$4,899 91

Respectfully submitted,

J. J. DAVIS, *Treasurer.*

REPORT OF COMMITTEE ON INSECT COLLECTIONS IN AMERICAN MUSEUMS.

In continuation of the plan of recent years requests were sent to about 60 different institutions where insect collections were maintained, with requests for information concerning recent additions and items of interest concerning collections, and where no previous report had been made, for a summary of the principal features of the collection.

Reference to previous reports with these additions gives us a quite comprehensive survey of the status of the principal collections for the United States and Canada.

United States National Museum: Dr. J. M. Aldrich, Associate Curator of Insects, furnishes the following statement: "The principal addition of the year has been the collection of the Brooklyn Museum of Arts and Sciences, reported in the Annals last year on page 155. This has been deposited here on account of the decision of the directors of the Museum to use all their facilities for educational work. We received just about what is listed in the Annals cited, something over 100,000 specimens, with types of approximately 1100 species. Other additions of noteworthy size and interest include 900 Lepidoptera from New Zealand, received

from Dr. Alfred Philpot; 500 Microlepidoptera from Jeane D. Gunder, Pasadena, California, 5,000 South American beetles, from G. L. Harrington, Argentina; over 2,000 Asiatic wasps and over 10,000 miscellaneous insects from the Bureau of Entomology; over 50,000 miscellaneous insects from George D. Dimmock, Springfield, Mass.; 5,000 beetles from L. L. Buchanan of the Bureau of Entomology; 2,000 Siamese insects from Dr. Hugh M. Smith, Bankok, Siam; 15,000 miscellaneous insects from China, collected by D. C. Graham. In addition, the Museum has recently received a large shipment of approximately 50,000 specimens which have not yet been accessioned; 2,000 Diptera of northern Europe, collected by myself; a growing number of outside entomologists make a practice of depositing their types here."

The American Museum of Natural History: During the past year The American Museum Collection of Insects has been enriched by specimens collected on expeditions to tropical America. The more important ot these being the Tyler Duida Expedition, 3100 specimens; Lee Garnet Day Mt. Roraima Expedition, 1100 specimens, and the Museum Expedition to the Panama Canal Zone, 7500 specimens. Our largest single donation consisted of a collection of more than 1000 named Diptera received from the Canadian Government, Department of Agriculture, through kindness of Dr. J. McDunnough. In addition to the above we have received numerous smaller lots of specimens which would make a total of nearly 20,000 specimens added to our collection during the year 1929. – FRANK E. LUTZ

Museum of Comparative Zoology: The principal additions during the year have been a collection of insects and arachnids made by Frank Werner in Algeria and Morocco, largely named and including a few types of Werner, and the large collection of myrmecophilous insects presented by Dr. W. M. Wheeler. Mr. Fairchild collected about 1,000 insects in Florida and the curator as many locally. With the aid of T. H. Hubbell, the United States Orthoptera have been arranged. The most important event was the accession of 1,000 new boxes. – NATHAN BANKS.

Boston Society of Natural History: In connection with some work preparatory to celebrating the one hundredth anniversary of the Society in 1930, a census of the New England collection of insects was made. The result showed 10,043 determined species and varieties, represented by over 62,800 specimens. The above figures include about 550 types, but do not include the Harris collection, containing about 4660 species (including 140 types) and 9750 specimens, nor, the exhibition series contained in 64, 24 x 30 inch, glass-covered cases.—CHAS. W. JOHNSON.

Massachusetts Agricultural College: The development during the last twelve months has been only that of such normal increase as might be expected, with the exception of a valuable donation of named Coleoptera from Mr. H. L. Frost of Framingham, Mass. No other important gifts or collections of any size have been added to the department, but the Coleoptera have been very largely rearranged and many new species worked into place.—H. L. Fernald.

Bureau of Plant Industry, Harrisburg, Pa.: The insect collection consists of about 50,000 specimens, representing approximately 10,000 species. The majority of these are Pennsylvania insects; the orders Coleoptera, Diptera, Lepidoptera and Hymenoptera are the best represented. The collection of pinned specimens is contained in modern cases similar to those used in the United States National Museum. The slide material and alcoholic collection are not so well represented. No intensive taxonomic work, extensive collecting or additions have been attempted during the past year but the collection is well cared for and preserved for general use. –R. H. BELL.

Agriculture Experiment Station, Newark, Delaware: The insect collection includes a wealth of undetermined material representing many groups, the result of collections from 1889-1899 by G. Harold Powell, from 1900 1902 by E. Dwight Sanderson, 1903–1925 by C. C. Houghton and from 1925-1929 by H. L. Dozier. The determined màterial comprises some 800 species of Coleoptera, a smaller number of Lepidoptera and Diptera and a series of the economic insects of Delaware arranged according to host plants for classroom use. At present the entire collection is most inadequately housed in the Department of Biology. Were facilities available for its determination, arrangement and display, it would constitute an excellent exhibit of the insect fauna of the state.– L. A. STEARNS.

The North Carolina State College of Agriculture and Engineering: Our collections during the past year have been enriched by considerable additions from Cuba, Mexico, Central and South America and Eastern South Africa.—Z. P. METCALF.

Alabama Polytechnic Institute: The collection is being transferred from the old style glass top insect trays to Schmidt boxes, some 120 boxes having been added to the insect museum this past year. There are approximately 20,000 specimens in the collection. Since July 1, 1929, Dr. Henry G. Good has been giving approximately one-fourth time to building up the insect collection, rearranging, and determining much of the unidentified material. The cataloging and counting of determined specimens has not been completed.—J. M. ROBINSON.

State Plant Board of Mississippi: During the past year Dr. C. E. Mickel has named and returned to us a number of specimens of Mississippi *Mutillidæ*. Among them were several new species, the types of which have been incorporated in our collection. Dr. M. R. Smith has continued the systematic study of the ants of Mississippi and reports that he has 120 species that have been collected in the state. About 5 per cent of them are new species that have been described and the types are in our collection. Mrs. Gladys Hoke Lobdell has continued her systematic studies of the scale insects of Mississippi and has described a few new species, the types of which are in our collection.—R. W. HARNED.

University of Nebraska: During 1929 the insect collection at this University received no very important additions, but did receive considerable attention along the line of improvement by rearrangement. Mr. O. S. Bare made considerable progress in rearranging the Coleoptera to conform with Leng's check list. A collection of South American Bembecid wasps sent to the U. S. National Museum in 1926 was identified by Dr. J. B. Parker and returned, including the allotype and several paratypes of *Trichostictia bruneri*. The collection of Formicoidea was named and rearranged by Mr. Bare, and the collection of Vespoidea, exclusive of the Mutillidæ which had been arranged by Dr. Mickel previously, was named and rearranged by Mr. Raymond Roberts, Instructor in the Department of Entomology.—MYRON H. SWENK.

Kansas State Agricultural College: Dr. Warren Knaus, who donated, several years ago, to this institution his large collection of Coleoptera, is now devoting his entire time to the reclassification and final arrangement of the insects before they are placed in the museum at the Kansas State Agricultural College. During the 47 years that Doctor Knaus has been collecting and studying beetles, he has brought together one of the greatest collections of the Coleoptera. No doubt it is the greatest collection of beetles in the Southwest. It contains more than 100,000 specimens representing about 10,000 species. More than 100 of them are new species taken by Doctor Knaus. Some of these new species are not found in any other collection.—GEO. A. DEAN.

Colorado State Agricultural College: The insect collection was started when the writer took charge of the Department of Zoology and Entomology in the spring of 1891. The plan has been through the years, first; to get together as representative a collection as possible of the insect fauna of the state and second; to make as complete a collection as possible of special groups upon which members of the department might be working. Most of the collecting during the past 15 or 20 years has been in these special groups. A summary of the collection shows 9586 species.—C. P. GILLETTE.

University of Kentucky Experiment Station: Collections of insects consists of over 52,000 pinned specimens kept in Schmidt or similar boxes and these in turn are inclosed in glass-front sectional cases. The approximate number is 52,385 specimens.—M. L. DIDLAKE.

Louisiana State University: A note from Professor W. E. Hinds states that "Arrangements are under way by which the C. H. T. Townsend collection of Diptera, containing especially large numbers of species of Tachinidæ, will be deposited by the Peruvian Experiment Station to which it belongs, in the U. S. National Museum in the near future. This disposition of this collection is made so that it may be made available for workers in Diptera who may be interested in it and will be safely cared for. It may be recalled to Peru in the future if that seems advisable."

State College of South Dakota: All collections are housed in the Entomological-Zoological Building. The collections from the State of South Dakota are excellent and fairly complete for most orders. Especially noteworthy is the collection of Orthoptera. This collection includes more than 125,000 pinned, named specimens. While the majority of these specimens were taken from the Great Plains States, the collection is also fairly complete for the states east of the Mississippi River, and for Oregon, Washington and British Columbia. In addition, the collection of Orthoptera includes many hundreds of species from Africa, Europe and Asia. The Truman collection of Lepidoptera and Coleoptera is now the property of the State College of South Dakota. This collection is made up of materials collected principally in the United States, Canada, Mexico, South and Central America, and the British Isles. While collections contain some types, we plan to present these to the U. S. National Museum in the near future.
—H. C. SEVERIN.

Cornell University: We note the following additions to our material, only the first item of which may be considered of very great importance. 1. A large collection of Chinese Odonata, including types. 2. An unstudied collection of Peruvian Hymenoptera. 3. Extensive collections of Scoliidæ, chiefly from Java and South America.—J. CHESTER BRADLEY.

Experiment Station of the Hawaiian Sugar Planters' Association Honolulu, Hawaii: The collections of local material contain practically all of the species of the lowlands and cultivated districts and besides a fairly good representation of the native insects of the mountain forests. These are chiefly in cabinets convenient for ready reference or study, and are continually being added to. Of foreign material, there is a large accumulation of Hymenoptera, Coleoptera, Diptera, Heteroptera, Homoptera, Lepidoptera (and lesser quantity of some other orders) secured by the entomologists of the Station while travelling in various foreign countries on parasite research work. These are largely from Australia, Malay Islands, Philippines and South America. The most of this material is stored in about 600 Schmidt boxes and has not been worked up and are arranged in a large cabinet. There are several hundred types. The Hemiptera are practically worked up and arranged in a few cabinet drawers. The wasps are partially worked up and occupy more than 50 Schmitt boxes. There is a large Coccinellid collection (over 20 boxes) the collections of the late Albert Koebele during the time that he was engaged in the introduction of beneficial insects into Hawaii. They are chiefly from Australia, Fiji, China, Java, Japan and Mexico. The Harford collection of American Coleoptera which had been acquired by Mr. Koebele is contained in 82 boxes on our shelves. We have also a collection of all boxes of named California Coleoptera collected by the late Mr. W. M. Giffard. The latest addition to the collection is the extensive collection of Curculionidæ of the world brought together and worked up during the life time of the late Dr. David Sharp of England. This collection of Curculionidæ occupies about 100 large-sized insect boxes, many of them double boxes. Altogether there are many thousands of specimens. No estimate has been made of them. There are over 1000 types chiefly in Fulgoroidea, Heteroptera, and Parasitic Hymenoptera.—O. H. SWEZEY.

Illinois State Natural History Survey, Urbana, Illinois: Although the collection has not been enlarged by any notable gifts during the past year, the insect collection of this institution has continued to grow. During the past year special attention has been devoted to the building up of the collection of plant lice, stoneflies and sawflies. Over 5,000 slides of Illinois species of plant lice made from live material were added to the slide series, making a collection now of over 10,000 slides in this family of insects. The collection of Plecoptera, or stoneflies, was increased by the addition of some thousand specimens of immature and adult insects which have been preserved in fluid. Our collection of sawflies was considerably augmented by the addition of much new material belonging to the genus Dolerus. Approximately 2000 pinned specimens of various groups were added to the general collection from various sources.—THEODORE H. FRISON.

Committee: HERBERT OSBORN, *Chairman*,
C. W. JOHNSON, E. C. VAN DYKE,
J. G. NEEDHAM, NATHAN BANKS.

REPORT OF THE MANAGING EDITOR OF THE ANNALS.

I wish to report that the ANNALS has been fortunate this past year in the quality of the articles submitted for publication, in the help given for special illustrations and in the receipt of a grant of $500.00 from the National Academy of Science. The annual volume now approaches 800 pages and will probably be as large in 1930. Ample material is in hand for the March issue and also articles for the June, 1930, issue.

In general we have tried to follow the policies worked out and found best by Professor Herbert Osborn during his development of the ANNALS to its present form and standing as a scientific journal.

I wish to speak my appreciation of Professor Osborn's continued interest. He has been at the Editor's right hand and has assisted during the summer when the Editor has been on his so-called vacation.

The financial summary follows:

RECEIPTS.

Non-member Subscriptions	$ 566.66
From Sale of Back Volumes and Numbers	299.70
From Engravings and Reprints	543.14
Volume 2, Say Foundation	5.00
From National Academy of Science	500.00
	$1,914.50

DISBURSEMENTS.

Mailing Charges and Postage Stamps	$ 93.68
Stenographic and Clerical Service	273.48
Engraving Bills	514.30
Incidentals	48.56
	$ 930.02
Remitted to Treasurer, December 10, 1929	970.16
Overdraft on Bank, January 1, 1929	14.32
	$1,914.50

Vouchers are submitted herewith.

Respectfully submitted,

CLARENCE H. KENNEDY, *Managing Editor.*

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION FOR THE YEAR 1929.

RECEIPTS.

Balance on Hand, January 1, 1929, (See ANNALS XXII, p. 151)	$13.13
Sale of Volume I	15.00
Sale of Volume II	27.95
Interest on Savings Account	.46
Total Receipts	$56.54

(Due on Sales of Vol. II, $5.50.)

EXPENDITURES.

Postage on Volumes Mailed	$ 2.40
Stamps	1.00
Interest on Loan of $325.00, January 1, 1929, December 30, 1929	19.50
Balance in Purdue State Bank	33.64
Total	$56 54

There is a balance due on loan to pay for printing of volume II, of $325.00. Total net deficit, $291.36.

Respectfully submitted,

J. J. DAVIS, *Treasurer.*

REPORT OF THE AUDITING COMMITTEE.

We, the Auditing Committee, have examined the books of the Thomas Say Foundation, the Treasurer of the Entomological Society of America, and the Managing Editor of the Annals, and have found them to be correct.

Respectfully submitted,

C. R. CROSBY, *Chairman*,
W. S. HAYES,
C. E. MICKEL.

By vote of the Society the report was accepted.

The report of the Committee on Anatomical Terminology (G. C. Crampton, Chairman, O. A. Johannsen and R. E. Snodgrass) was received and after much discussion was referred back to the committee with the request that the committee circularize their report among the members and report back a year hence.

No report was received from the Historical Committee. (This committee was approved at the last meeting of the Society and the following members were appointed by President Brues: Nathan Banks, Chairman, A. C. Kinsey and A. L. Quaintance.)

The Committee on Coordination (Raymond C. Osburn, Chairman, A. L. Melander and J. J. Davis) reported excellent cooperation with the similar committee of the American Association of Economic Entomologists in avoiding serious program conflicts.

Representatives on the Council of the Union of American Biological Societies (A. N. Caudall and A. G. Boving) presented the report of J. R. Schramm, Editor of Biological Abstracts.

R. H. Van Zwaluwenburg was appointed last spring to represent the Society at the Fourth Pacific Science, held in Java. The notification reached Mr. Van Zwaluwenburg just after the meetings and too late to be presented to Congress. However, he very kindly submitted a brief report which was read to the Society.

The special committee on Nomenclature appointed by the President at the opening session to consider proposed amendments of the Zoological code, recommended, through the Chairman, Theo. D. A. Cockerell, that more time be granted and suggested their report be submitted at a later date to the Secretary for proper transmissal. Approved.

Publication of the membership list and the present Constitution and By-Laws approved.

REPORT OF THE RESOLUTIONS COMMITTEE.

Your Committee submits the following resolutions:

1. That we express to the local committee and to the authorities of the Iowa State College our appreciation of their hospitality and of the many courtesies extended to the members of this society.

2. That we commend the action of the Legislature of the State of Iowa in recognizing the value of scientific meetings by appropriations towards the expenses of this gathering.

Respectfully submitted,

E. D. BALL, *Chairman*,
C. L. METCALF,
C. P. GILLETTE.

REPORT OF THE NOMINATING COMMITTEE.

The Nominating Committee beg to report the following as nominees for the respective offices for the year 1930:

President—EDITH M. PATCH.
First Vice-President—R. E. SNODGRASS.
Second Vice-President—R. W. DOANE
Secretary-Treasurer—J. J. DAVIS.
Additional Members of Executive Committee—
For term expiring December 31, 1932—C. L. METCALF and P. J. PARROTT.
Councillors to the American Association for the Advancement of Science—
W. A. RILEY and A. L. MELANDER.

By vote of the society the report was accepted and the Secretary instructed to cast the unanimous ballot of the Society for the election of the persons nominated.

The meeting then adjourned.

Respectfully submitted,

(Signed) J. J. DAVIS, *Secretary.*

BOOK NOTICE.

A HANDBOOK OF THE MOSQUITOES OF NORTH AMERICA, by Robert Matheson pp. I-XVIII-268. 23 figures, 25 plates. Charles C. Thomas, Springfield, Illinois.

This is a brief and beautifully printed handbook of the mosquitoes of North America, of the problems they bring to economic entomology and of the methods of their solution. The material is very well organized so that it makes a very readable book as well as a handbook in which specific topics can be readily located. The chapter headings indicate the contents: I, Characteristics of Mosquitoes; II, Biology of Mosquitoes; III, Mosquitoes and Human Welfare; IV, Mosquito Reduction; V, Collecting and Rearing; VI, Systematic; VII, Systematic. Apparently the author sinks a good many of the Dyar and Knalb species. The bibliography lists only twenty-two references but indicates those references having extensive bibliographies. The volume is obviously a very concise summary and key to the extensive literature on mosquitoes.

C. H. KENNEDY.

ANNALS
OF
The Entomological Society of America

Volume XXIII JUNE, 1930 Number 2

TWELVE NEW MEALYBUGS FROM MISSISSIPPI.
(Homoptera: Coccoidea.)*

GLADYS H. LOBDELL.

Of the species described in this paper one is a Phenacoccus, two are members of the genus Pseudantonina, four of the genus Pseudococcus, and five of the genus Trionymus. The ants attending these mealybugs were determined by Dr. M. R. Smith.

In a forthcoming paper I recognize the families (1) Diaspidæ and (2) Aclerdidæ of Professor Ferris, the (3) Coccidæ of Mr. Steinwenden, and the (4) Margarodidæ and Ortheziidæ of Dr. Morrison. These groups are based on old subfamilies or genera. It thus becomes necessary to consider as a family also the group Pseudococcinæ, even though it has but within the past year been defined and elevated to subfamily rank by Dr. Morrison (5). Professor Ferris (6) has discussed most of the genera that are at present recognized as belonging to this group.

Pseudococcidæ.

This group is composed of those genera which have one or two pairs of dorsal ostioles, and which typically have small triangular and usually trilocular pores. A common characteristic of many of the members of this family is a covering of cottony or mealy secretion and the presence usually of at least one pair of cerarii.

*Contribution from the Entomology Laboratory of the Mississippi Agricultural Experment Station and State Plant Board of Mississippi. The drawings were made by Mrs. G. G. DeBord, of the DeBord Laboratories, Fort Smith, Arkansas.

Phenacoccus insignis new species.

(Plate I, Figures 1–7.)

Larva.—Body of mounted specimens examined .79 to .85 mm. long, about .46 mm. broad; antennæ six-segmented; tibiæ shorter than tarsi, claws long and slender, each with a denticle; tentorium well developed, ventral surface with quinquelocular disc pores, those of abdomen in transverse rows; dorsal surface with setæ constricted at base, and with trilocular pores; position of cerarii indicated by presence of spines and pores, numbers not determined, anal lobe bearing two large cerarian spines and about three pores, ventral surface of anal lobe with one short and one long seta; anal ring setæ about five-eighths as long as anal lobe setæ.

Adult female.—Body of specimens mounted on slide 3.24 to 3.42 mm. long, 2.31 to 2.64 mm. broad; antennæ nine-segmented; eighth and ninth segments less distinctly separated than preceding segments, seventh and eighth segments subequal in length, distal segment slightly longer; tentorium well developed; legs of usual type, front tibia two and one-third times as long as tarsus, hind tibia three and one-third times as long as tarsus, claw with large denticle, dorsal setæ not numerous, small, constricted at base, ventral setæ of usual type, in transverse rows, about five groups of one long and one short seta on each segment; dorsal and ventral surfaces with trilocular pores, ventral surface with quinquelocular pores in transverse rows and also multilocular pores in region of vulva, seventeen pairs of cerarii, apparently located on slight protuberances, cerarian spines small, varying in number and size, usually about two larger and one to ten smaller, constricted at base, pores more numerous than on adjacent surface but more than their own width apart; a larger or medium sized ceratuba, or possibly more, apparently on each segment on margin, opening to surface through a chitinized protuberance, resembling in shape a frustrum of a cone, which apparently usually bears two stout setæ near base, some segments with additional similar ceratubæ near meson, number apparently variable; anal ring cellular, with two outer rows of cells, in places three rows, single inner row; ventral surface of anal lobe bearing usually one long, two medium, and two small setæ; four smaller setæ located on or near mesal margin of small chitinized area; six anal ring setæ, about two-thirds as long as anal setæ, ovoviviparous.

Host.—Elm bark (*Ulmus* sp.).

Locality.—Columbus, Mississippi: November 30, 1926.

Collected by Dr. M. R. Smith and Mr. J. N. Roney.

Attended by ants (*Crematogaster laeviuscula* var. *clara* Mayr.)

The pores of the cerarii are apparently more numerous in this species than in *Phenacoccus regnillohi* Holl, and there is a distinct chitinized area on the ventral surface of each anal lobe. The original description does not mention this chitinization.

Dr. Morrison says, "I cannot associate this specimen with any species in the collection. From descriptions, it seems closest to *regnillohi* Holl."

The holotype is in the coccoid collection of the Mississippi State Plant Board; paratypes in the same collection: and in the coccoid collection of the U. S. National Museum.

Pseudantonina giganticoxa new species.

(Plate II, Figures 1–6.)

Living adult females.—About 1.8 to 2.19 mm. long, 1.4 to 2.19 mm. broad, 1.00 mm. high, yellowish white color with practically no secretion on January 10, when brought into the laboratory, segmentation of thorax and abdomen distinct. Four specimens left in vial until morning after collection had secreted a quantity of white cottony wax threads which entirely surrounded the body extending for about twice the length of the body caudad of it. One specimen had only secreted a small quantity of fine white powdery wax and a few threads. On January 17, the wax on one specimen stood 7 mm. high and curved caudad, the total length equaling the height. The specimens were not fed.

Adult female.—Specimens mounted on slides, 1.91 to 3.11 mm. long, 1.55 to 3.11 mm. broad, very convex; derm membranous except along coria between segments, there irregularly chitinized on thorax and abdomen; antennæ reduced but not rudimentary, usually six-segmented, occasionally with four or five segments; setæ of basal segments short and stout, those of distal segments slenderer; tentorium and rostrum each about as broad as long, heavily chitinized; spiracles broad, heavily chitinized, with numerous multilocular disc pores and a few smaller, circular trilocular pores, in close proximity, legs reduced and poorly devloped but not rudimentary, claws very slender, without denticles, digitules hair-like; a pear-shaped portion of ventral derm—apparently a prolongation of each coxa—chitinized, slightly less than twice as long as rest of leg, and perforated with numerous small clear pores; dorsal surface with a few small stout setæ and numerous short, chitinized, tubular ducts, setæ most numerous along lateral margins and on posterior half of abdomen, with two pairs of small dorsal ostioles; setæ of ventral derm more numerous and larger, those of abdomen arranged in transverse rows segmentally, longest in region of vulva; multilocular disc pores, and short tubular ducts of dorsal type numerous, anal lobes very reduced, bearing on dorsal surface numerous setæ of type occurring on adjacent areas, some perhaps slightly larger, those of ventral surface slender, each anal lobe seta short; anal ring cellular, chitinized, broad, with six short setæ about size and length of anal setæ.

Host.—Apparently *Cyperus ovularis* or *echinatus.*

Locality.—A. and M. College, Mississippi: January 9, 10, 1929.

Dr. M. R. Smith, Collector.

Attended by or associated with ants: *Prenolepis* (*Nylanderia*) *parvula* Mayr.

This species is distinguished from any described species by the extremely large chitinized hind coxæ, bearing pores on their ventral surfaces, and by the irregular chitinization of the coriæ of thorax and abdomen. On a few specimens two or three of the dorsal setæ of the anal lobes were larger than the others, resembling cerarian spines. As this is not a constant condition, I have considered the cerarii as lacking.

The holotype is in the coccoid collection of the Mississippi State Plant Board; a paratype in the collection of Mr. E. E. Green.

Pseudantonina spirapuncta new species.

(Plate III, Figures 1–9.)

Sac.—Adult female enclosed in a white felted sac.

Adult female.—Specimens mounted on slides 1.38 to 1.71 mm long, 1.00 to 1.38 mm. broad; derm apparently usually membranous except anal extremity; antenna small, six-segmented, attached near margin of head and about twice the width of a basal segment apart; eyes protruding slightly; tentorium slightly longer than broad, rostrum as broad as long, apparently two-segmented; spiracles conspicuous, peritremes densely chitinized with an irregular row of pores between lateral edge and spiracular opening; legs small, each hind leg with numerous large, indistinct, clear areas on femur and tibia, distal end of tibia much broader than adjacent end of tarsus; tibio-tarsal articulation distinct; claw slender, without denticle, ungual digitules enlarged at distal end, tarsal digitules hair-like; anterior dorsal ostioles apparently lacking, posterior pair small; ventral coriæ cephalad of second and of third abdominal segments with a conspicuous circular cicatrix heavily chitinized around edge, anterior one larger; dorsal and ventral derm with numerous multilocular pores, what appears to be trilocular pores and a few smaller pores, tubular ducts about same diameter as large pores, setæ stout, segmentally arranged, not numerous, lateral margins of posterior three or four abdominal segments with one to three long setæ; anal seta small, anal ring broad, heavily chitinized, densely cellular, six long anal ring setæ, anal setæ about one-half as long as anal ring setæ.

Host.—Grass roots.

Locality.—A. and M. College, Mississippi: November 28, 1927.

Collected by Dr. M. R. Smith and Mr. W. A. Douglass.

The species can be distinguished from *parrotti* by the absence of the grouped pores laterad of, though in close proximity to, the peritremes of the spiracles; by the presence of multilocular pores in the peritremes of the posterior pair of spiracles; by the larger legs which are well developed though small; and by the presence of two structures, apparently cicatrices, on the ventral meson, one between the first and second abdominal segments, and a smaller one between the second and third segments.

I am indebted to Mr. E. E. Green for calling my attention to the fact that this is a new species and not the same as *P. parrotti*. Some unmounted material was sent to Mr. Green as *P. parrotti* together with a mount of *parrotti*. Careful examination of the material in the collection reveals the fact that there are two lots of material bearing the same data, one lot being *parrotti*, the other *spirapuncta*. Although there was nothing on the labels to indicate that the material was not the same, Dr. Smith is of the opinion, and I agree with him, that if the two species had been collected in the same immediate vicinity the material would have been in one package and not in two.

The Holotype is in the coccoid collection of the Mississippi State Plant Board, and some of the material in the collection of Mr. E. E. Green.

Pseudococcus acutus new species.

(Plate IV, Figures 1-8.)

Living adult female.—Enclosed in a greenish white, resinous cell, usually about two to three mm. long and open at the distal end; posterior portion of the abdomen of living specimens protruding from the cell, its unusual pointed form being quite as distinctive in a living specimen as in a mounted one; the bands of large multilocular abdominal pores conspicuous on a mounted specimen, appear to be restricted to the portion of the abdomen which usually projects from the resinous cell. These cells were attached to the twig near the base of the needles.

Adult female.—Bodies of fourteen specimens mounted on slides measured 1.6 to 2.17 mm. long, .97 to 1.45 mm. broad; broadest through mesothorax, abdomen tapering sharply to posterior end, anterior end of body rounded; surface of body powdered with fine white wax; derm membranous; antennæ seven-segmented, distal longest; tentorium and legs of average sizes, each posterior tibia usually slightly more than twice as long as tarsus, tibia scattered with a few clear pores; spiracles small; anterior and posterior dorsal ostioles present; trilocular pores

scattered on dorsal and ventral surface; ventral surface of head and thorax with a few scattered multilocular disc pores, margins of ventral surface of first two or three abdominal segments with a few pores, each remaining segment of abdomen with transverse row of pores along caudal margin extending onto dorsal surface and forming a continuous band except on third and possibly on fourth segment, a few ducts on abdomen; margins of abdominal segments bearing cerarii consisting of a few trilocular pores and two small cerarian spines, anal cerarii with about eight pores, preceding segments with successively fewer pores; cerarian spines possibly occurring on thorax and head but apparaently lacking; dorsal and ventral surfaces with scattered setæ, most abundant on posterior half of abdomen; anal lobes much reduced, anal setæ slightly longer than ventral pair of anal ring setæ, median pair of anal ring setæ shortest, dorsal pair slightly longer than median; anal ring large, dorsally located.

Host.—Pine twigs (*Pinus* sp.).

Locality.—Ocean Springs, Mississippi; March 28, 1927.

Mr. J. P. Kislanko, Collector. S. R. No. 4681.

This species can be distinguished from any species I know by the relatively large multilocular disc pores on the dorsal as well as the ventral surface of the abdomen, the small ducts, and the relatively inconspicuous cerarii.

Specimens of a species, which, with the exception of a normally shaped abdomen instead of a pointed one and an absence of a resinous cell, is very similar to if not the same as *acutus* were collected by Mr. J. M. Langston under flakes of bark of a pine on the Horticultural Department Grounds, A. and M. College, Mississippi, August 3, 1927. These were attended by ants.

The types are in the coccoid collection of the Mississippi State Plant Board.

Pseudococcus dentatus new species.

(Plate V, Figures 1–5.)

Adult female.—Body mounted on slide 1.65 to 2.40 mm. long, .95 to 1.45 mm. broad; derm membranous; antennæ eight or seven-segmented; legs of average size, hind coxæ with numerous rather large clear areas, trochanters, femora, tibiæ, tarsi, and each segment of fore and midlegs with few indistinct clear areas, tibiæ with two large, heavy spines, claws frequently with a small but definite denticle; spiracles of usual type; rostrum about three-fourths as broad as long; derm scattered with trilocular pores and setæ, setæ of dorsal surface short, not numerous, arranged in transverse rows, ventral setæ longer especially on meson; a few large tubular ducts with chitinized raised rims around mouth on lateral and dorsal surface apparently segmentally arranged; lateral

margins of segments with clusters of small tubular ducts, most numerous on posterior abdominal segments and on head; ventral surface of abdomen with numerous large multilocular disc pores, abdomen usually with five to seven pairs of cerarii consisting of two slender cerarian spines and about four trilocular pores, pores and setæ reduced towards thorax, pores more numerous and setæ larger on anal lobes and derm apparently slightly chitinized with two or three slender accessory setæ, ventral surface with three short setæ, a slight chitinized bar extending cephalad from each anal seta, anal setæ slightly longer than anal ring setæ, one specimen with fourth pair of small anal ring setæ located in close proximity to ventral pair, anal ring of usual Pseudococcine type with a single row of outer cells between first and third pairs of setæ.

Host.—Ragweed (*Ambrosia* sp.) roots.

Locality.—A. and M. College, Mississippi: November 28, 1927.

Collected by Dr. M. R. Smith.

Attended by ants (*Pheidole vinelandica* Forel).

This species differs from any other that I know in usually having a denticle on the claws, tubular ducts with chitinized raised rims around the mouths, and with cerarii restricted to the abdomen.

The types are in the coccoid collection of the State Plant Board.

Pseudococcus difficilis new species.

(Plate VI, Figures 1-9.)

Living specimens.—Entire body covered with fine white, powdery wax, in rubbed specimens, derm showing through as light brown in color; largest specimen examined 2.6 mm. long, 2 mm. broad, smallest specimens 2 mm. long; segmentation distinct; eight or nine wax pencils projecting from abdominal segments, increasing in size toward anal lobes; longest pencil .4 mm., two pairs on head, apparently none on thorax; two short flat wax plates protruding from lateral and ventral half of anal ring apparently united on ventral surface, one specimen with a drop of light amber-colored fluid above left posterior ostiole, fluid quickly volatile when surface film was punctured, or quickly absorbed by bark on which specimen rested.

Larva.—Body of specimen examined .56 mm. long, derm membranous; antennæ large, six-segmented; legs large, claws without denticle; spiracerores apparently lacking, two pairs of dorsal ostioles, large; dorsal and ventral surfaces with trilocular pores; one pair of cerarii, on anal lobe, bearing two long stiff spines and cerores placed close together; six anal ring setæ apparently longer than anal lobe setæ.

Adult female.—Specimens mounted on slide slightly longer than broad, 2.1 to 2.6 mm. long, 1.8 mm. broad; derm thin and membranous; antennæ eight-segmented, distal segment longest; legs of average size,

posterior aspect of hind femur and of tibia with numerous clear areas or pores, tibia 2.5 to 3 times as long as tarsus, claw without denticles; trilocular pores on dorsal and ventral surface; circular pores on ventral surface of abdomen more numerous near vulva, small tubular ducts on ventral surface; spines not constricted at base, long and slender, especially on ventral surface; six anal ring setæ, anal lobe seta usually same length as anal ring setæ; ventral surface of anal lobes with large chitinized area bearing several short and one or two long setæ; apparently ten to twelve pairs of cerarii, exact number difficult to determine, usually two pairs on head and eight or nine pairs extending cephalad from anal lobes, cerarian spines range in size from small to large, exact number of each size difficult to determine, first pair of cerarii usually with 4 to 5 long and 2 to 4 short spines; second pair with 4 long and 5 short spines, occasionally a single large spine that apparently represents third pair; fourth pair, 1 to 2 when present; fifth pair, 1 to 3 long, 1 to 3 short; sixth, 0 to 4 long, 1 to 5 short; seventh, 1 to 4 long, 3 to 6 short, eighth, 1 to 4 long, 4 to 7 short; ninth, 2 to 3 long, 3 to 8 short; tenth, 2 to 3 long, 3 to 9 short; eleventh, 2 long, 5 to 14 short; twelfth, or anal lobe pair, 2 to 3 long, 1 to 4 short; cerarii with about 0 to 4 accessory setæ and with grouped triangular pores numerous, about 9 in fifth pair and increasing toward anal lobe cerarii where they number about 100; last six or seven pairs of cerarii usually with derm more or less chitinized.

Host.—Ash. (*Fraxinus* sp.). Most abundant near scarred places on trunk.

Locality.—In front of Biology Building, A. and M. College, Mississippi: August 28, 1926.

Collected by Mr. J. M. Langston.

Description of larva and of living adult females are from specimens taken in crevices of bark of ash, Mayhew, Mississippi, November 11, 1926, by Dr. M. R. Smith. These specimens were attended byArgentine ants (*Iridomyrmex humilis*, Mayr.). Specimens at A. and M. College were attended by fire ants (*Solenopsis geminata* Fabr.).

Dr. Harold Morrison says, "I have not succeeded in associating this with any species in the collection, nor do described species seem at all closely related."

The types are in the coccoid collection of the Mississippi State Plant Board.

Pseudococcus obesus new species.

(Plate VII, Figures 1-4.)

Unmounted adult female.—Living specimens plump, measuring 3.28 to 4.38 mm. long, 2.20 to 2.92 mm. broad, 1.80 mm. high; covered with fine white, powdery wax, easily rubbed off, showing through as reddish

flesh color, segmentation distinct; white waxy marginal pencils small, a pair on anterior end, usually two on sides of thorax and nine consecutive pairs on posterior half of body.

Adult female.—Body mounted on slide 3.02 to 4.19 mm. long, 2.00 to 3.20 mm. broad; derm membranous, antennæ eight-segmented; legs stout, hind tibiæ slightly more than twice as long as tarsi and with numerous rather large clear areas, coxæ and femora without clear areas; spiracles with a few pores; rostrum about two-thirds as long as tentorium, latter about four-fifths as broad as long; two pairs of dorsal ostioles; derm with numerous trilocular pores and small setæ, setæ longest on posterior end of abdomen, ventral surface of abdomen near vulva with numerous multilocular disc pores and small tubular ducts; each cerarius consisting of short cerarian spines, long slender accessory setæ, and numerous trilocular pores usually less than their own width apart, cerarii of fourteen specimens examined, arranged: one on head, three on thorax, and eight on abdomen; nine specimens showed one to two smaller cerarii, paired in only one instance, these being between last two thoracic groups, variation as follows:

	Head					Thorax	
C. S.	2–5	0–1	1–4	0–0 to 2	1–4	0–2	1–4
A. S.	0–4	0–2 to 3	1–5	0–0 to 3	1–5	0–2 to 3	1–3
P.	23–42	0–1 to 7	28–35	0–3 to 9	28–35	0–8 or 36	9 or 18–43

				Abdomen			
1–4	2–5	2–6	3–7	3–6	2–5	2–6	2–2 or 3
1–5	0–6	0–5	0–4	0–4	0–3	0–4	4–6
15–50	26–44	25–48	37–54	33–57	32–53	50–60	95–117

Anal lobes not well developed, dorsal surface without chitinization, ventral surface bearing a long anal seta and about ten shorter slenderer setæ and a small slightly chitinized area cephalad of shorter setæ; anal ring setæ two-thirds as long as anal setæ.

Host.—Pine (*Pinus* sp.) trunk, under flakes of bark or around scarred places.

Locality.—Meridian, Mississippi: November 14 and 23, 1927. Collected by Dr. M. R. Smith.

Attended by Argentine ants (*Iridomyrmex humilis* Mayr.)

This species is very similar to *P. morrisoni*, but apparently differs from it in having only a few clear areas on the hind femora, these sometimes apparently lacking, in having a much larger number of trilocular pores (usually more than thirty) associated with each cerarius; and in having only a very small, slightly chitinized area on the cephalic end of the ventral surface of the anal lobes.

The holotype is in the coccoid collection of the Mississippi State Plant Board; paratypes in the same collection and in the collection of the U. S. National Museum.

Trionymus claviseta new species.

(Plate VIII, Figures 1–5, and Plate IX, Figures 1–8.)

Adult female.—Bodies of specimens containing embryonic larvæ 1.98 to 2.31 mm. long, 1.32 to 1.58 mm. broad; derm membranous; antennæ seven-segmented, third or fourth segment usually with more or less indication of division; legs of usual type, front tibia 1.3 to 1.9 times as long as tarsus, hind tibia 1.7 to 2.0 times as long as tarsus, hind coxa with a few small translucent pores, latero-ventral spines on distal end of tibia small; tentorium broad, well developed, rostrum two-segmented; spiracles apparently without grouped pores; derm with numerous setæ, those of dorsal surface often slightly enlarged at tip, apparently never tapering to a fine point as do those of the ventral surface, segmentally arranged on abdomen; numerous trilocular pores on dorsal and on ventral surfaces, ventral surface with large multilocular pores on abdomen near vulva, a very few small multilocular (?) pores on ventral surface of body; a few small tubular ducts on ventral surface; dorsal surface occasionally with a large tubular duct opening to the surface through a pore with a chitinized rim and with about three to five small setæ in close proximity; posterior end of abdomen with three or four or possibly occasionally more of the same type, position and number variable; cerarii lacking except anal lobe pair, each with two large spines on a slightly chitinized area with about six or seven slender accessory setæ, ventral surface of anal lobe with a small chitinized area bearing one or two medium sized setæ, laterad of it three or four similar setæ, one long anal lobe seta; anal ring of usual *Pseudococcine* type, with usually six setæ, one specimen with seven, anal ring setæ two-thirds as long as anal lobe setæ.

Host.—Hackberry (*Celtis mississippiensis* Bosc.) bark.

Locality.—Mayhew, Mississippi: November 12, 1926. Collected by Dr. M. R. Smith.

Attended by ants (*Crematogaster* sp.).

The distinguishing characteristics of this species are: the bluntly pointed or slightly clavate dorsal setæ, a small chitinized area on the ventral surface of each anal lobe, and a single pair of cerarii, these located on the anal lobes, consisting of two large spines each.

The holotype and paratype are in the coccoid collection of the Mississippi State Plant Board.

Trionymus mori new species.

(Plate X, Figures 1–7.)

Adult female.—Body mounted on slide 1.98 to 2.18 mm. long, 1.18 to 1.22 mm. broad, derm membranous; antennæ eight-segmented; legs of normal size, hind coxa with numerous clear areas or pores on lateral aspect; femur with rather stout setæ, tibia with a few pores,

claw without denticles, digitules well developed; tentorium as broad as long, rostrum about five-eighths as broad as long, two-segmented; spiracles slender without grouped pores; setæ not numerous; trilocular pores on dorsal and ventral surfaces, a few multilocular pores on head and on ventral surface of abdomen, most abundant near vulva, small tubular ducts most abundant on lateral margins of segments, most numerous on head and abdomen, extending in transverse rows across ventral surface of abdomen; large tubular ducts not numerous but usually with one or more occurring on lateral margins and on dorsal surface of each segment; three dorsal to each segment except first three, sixth, and last three, cerarii restricted to abdomen, number of pairs varying, usually two or three posterior pairs recognizable or sometimes with as many as six on one side, anterior pairs recognizable chiefly by the position of the two cerarian spines which become more seta-like anteriorly; derm around base of the two spines of the anal lobe cerarii chitinized, bearing a few trilocular pores and two or three slender accessory setæ; a chitinized bar extending cephalad from each long anal lobe seta; anal ring setæ about three-fourths as long as anal lobe setæ.

Host.—Mulberry (*Morus* sp.).

Locality.—West Main Street, West Point, Mississippi (Property of B. L. Meyers): July 7, 1928. Collected by Mr. G. L. Bond.

This species can be distinguished from *Trionymus shaferi* (Hollinger , 1923) by the presence of a chitinized bar on the ventral surface of each anal lobe and by the chitinization of the derm of the anal cerarii.

The types are in the coccoid collection of the Mississippi State Plant Board.

Trionymus rostellum new species.

(Plate XI, Figures 1–7.)

Adult female.—Bodies of 16 mounted specimens varying from 2.24 to 3.70 mm. long, 1.02 to 1.72 mm. broad; derm membranous; antennæ eight-segmented; legs of usual type, slender, hind coxæ of usual shape and with clear pores rather numerous, setæ stout, tibia twice as long as tarsus; tentorium small, seven-eighths as broad as long, rostrum two-segmented, short, as broad as long, one-half as long as tentorium, bearing fourteen pairs of setæ, four pairs on ventral surface of proximal segment and seven pairs on ventral surface and three on dorsal surface of distal segment; spiracles small about twice as long as broad with few if any grouped pores; anterior and posterior dorsal ostioles small; setæ not numerous; segmentally arranged; trilocular pores fairly numerous on both dorsal and ventral surfaces, multilocular pores on ventral surface of last five abdominal segments with a few on the third and on thorax between anterior leg and spiracle, apparently never any on the head;

a small circular ventral cicatrix between third and fourth abdominal segments; tubular ducts of two sizes, small and medium size, not numerous, a few medium sized ones on head and along margins, small ones segmentally arranged, most abundant on posterior half of ventral surface of abdomen, cerarii lacking except on anal lobes, each consisting of two stout spines with about six associated pores; ventral surface of anal lobe without chitinization, with one long anal seta; 6 anal ring setæ about five-ninths as long as anal seta.

Host.—Crab grass (?), nut grass.

Locality.—Near hospital, Houston, Mississippi: October 23, 1929.

Collected by Dr. M. R. Smith.

This species was also collected by Dr. Smith on wire grass (*Elusina indica*) at Eupora, October 19, 1929. These specimens were quite abundant on the grass between the leaf sheath and the stem and crawling on the surface of the ground. Some of the females contained eggs. This species differs from *shaferi*, with which it might be confused, by the absence of a conspicuous, or enlarged, shoulder on hind coxæ; by the absence of multilocular pores on the head; by the presence of a small group of multilocular pores on the ventral surface between the anterior leg and spiracle; and by the much shorter rostrum. In this species the rostrum is one-half as long as the tentorium while in *shaferi* it is approximately the same length.

The holotype and paratypes are in the coccoid collection of the Mississippi State Plant Board.

Trionymus setosus new species.

(Plate XII, Figures 1-5, and Plate XIII, Figures 1-5.)

Living adult female.—Thickly covered with fine, white, powdery wax.

Larva.—Body mounted on slide .53 mm. long, .27 mm. broad; antennæ six-segmented; each tibia four-fifths as long as tarsus, claw without denticle, anal lobe bearing a cerarius with two cerarian spines, no accessory setæ, posterior dorsal ostioles distinct, six anal ring setæ, slightly more than one-half as long as anal lobe setæ; triangular pores and setæ arranged in transverse rows on abdominal segments.

Immature female.—Body mounted on slide 1.45 mm. long, .85 mm. broad; antennæ six-segmented; legs stout, coxa and femur broad, tibia slightly longer than tarsus, claw without denticle; spiracles medium or small in size; derm membranous, dorsal and ventral surfaces with triangular pores and slender setæ; large tubular ducts opening on dorsal surface through pores of multilocular type as in figure, with chitinized rims and usually with about two long, curved accessory setæ; specimens examined with ten or eleven on one margin and with

thirteen on the other, apparently lacking on anal lobes but with two on preceding segment, apparently one on meson of meso- and meta-thorax and of each of two segments cephalad of posterior dorsal ostioles, possibly others; setæ of dorsal surface with blunted tips, those of ventral surface pointed; only one pair of cerarii, these on anal lobes, with two long conical spines, about two accessory setæ, and a few trilocular pores; ventral surface of lobe with one long and two short setæ; anal ring cellular, of usual Pseudococcine type; anal ring setæ slightly more than one-half as long as anal lobe setæ.

Adult female.—Specimens mounted on slide about 3.7 to 4.2 mm. long, 1.9 to 2.3 mm. broad; derm membranous; antenna eight-segmented, distal segment longest, basal segment long and only slightly broader than second segment; legs of usual Pseudococcine type, claw without denticle; spiracles medium large; derm with numerous trilocular pores and long setæ; posterior dorsal ostioles large; margin with about fifteen pairs of tubular ducts, number apparently variable, opening through pore with chitinized rim, usually with about four accessory setæ; a few ducts of same type on dorsum of thorax and abdomen; anal lobe slightly chitinized; usually with two or four long cerarian spines, about two accessory setæ, and numerous trilocular pores, other cerarii lacking, margins of third and fourth abdominal segments cephalad of anal lobes apparently with clusters of setæ which extend onto dorsal surface toward meson, clusters decreasing in size cephalad; anal ring setæ apparently variable in number, ranging in specimens observed from twelve to thirty-six, typically with three pairs of long setæ as in typical Pseudococcine forms and with a variable number of smaller setæ located between larger ones, smaller setæ about one-half as long as large ones, large ones about one-half as long as longest anal seta; anal ring with single outer row of cells extending from cephalic pair of setæ ventrad to near last pair of large setæ; ventral surface near vulva with numerous setæ about same length as anal ring setæ.

Host.—Sweet gum (*Liquidambar styraciflua* L.) near roots in "cowsheds" built by ants.

Locality.—Durant, Mississippi: September 18, 1926. Collected by Mr. G. R. Williams.

The specimens were attended by ants which had built "cowsheds" over them. The descriptions of the larva and the adult female were made from material collected September 28. The immature female was kept on sweet gum at A. and M. College, until October 26, when the mount was made.

This species differs from any described species with which it might be confused in the large number of anal ring setæ.

Attended by Argentine ants (*Iridomyrmex humilis* Mayr.).

The holotype is in the coccoid collection of the Mississippi State Plant Board; paratypes in the same collection and in the collection of the U. S. National Museum.

Trionymus varus new species.
(Plate XIV, Figures 1–5.)

Embryonic larva.—Antennæ six-segmented, one pair of cerarii, on anal lobes, consisting of two cerarian setæ; anal ring setæ about five-ninths as long as anal lobe setæ.

Third (?) *stage female.*—Body 1.38 mm. long, antennæ seven-segmented, legs stout, posterior coxæ with clear areas; setæ and pores of dorsal and ventral surface and of cerarii fewer than in adult; otherwise very similar to next stage.

Adult female.—Body of specimens mounted on slide 2.78 mm. to 3.20 mm. long, 1.90 to 2.40 mm. broad; derm membranous; antennæ eight-segmented, distal segment longest; legs short and stout, hind coxæ with small clear circular areas on lateral side, tibiæ with a few clear areas near distal end on outer edge, tarsi about three-fifths as long as tibiæ, digitules slightly longer than claw, spiracles broad; tentorium small but stout, rostrum two-segmented, large, longer than tentorium; dorsal derm with numerous small trilocular pores and small setæ, ventral derm with similar but fewer pores and longer setæ; lateral margins with small clusters of clear irregular-shaped areas segmentally arranged, ventral derm adjacent to vulva with multilocular disc pores and with small tubular ducts along last four coriæ; cerarii restricted to anal lobes, each consisting of two slender cerarian spines with about seventeen long flexible accessory setæ, numerous trilocular pores and about an equal number of less distinguished quinquelocular (?) pores or pore-like structures of different sizes; ventral surface of lobes with one long and numerous shorter setæ; anal ring with six setæ of approximately same size, frequently with a seventh small accessory seta between dorsal and median setæ on one side; anal ring setæ about two-thirds as long as anal setæ; ovoviviparous.

Host.—Oak (*Quercus* sp.).

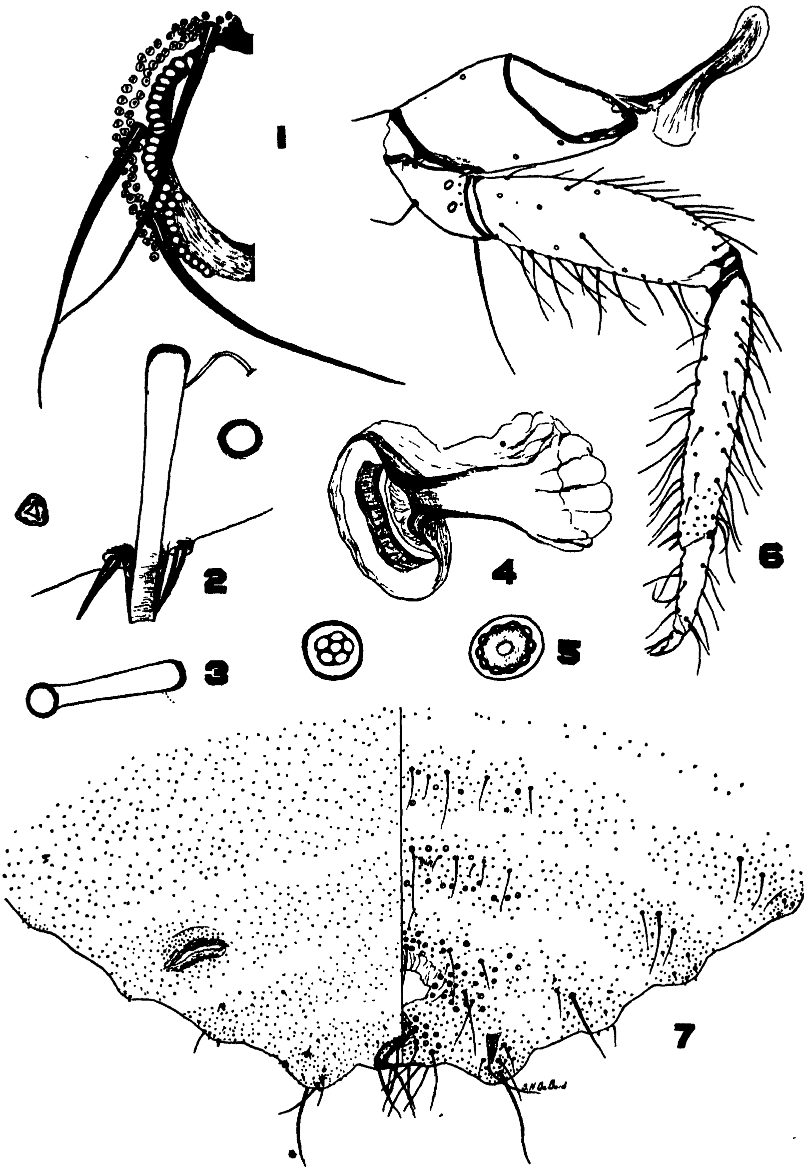
Locality.—West Point, Mississippi: August 30, 1927. Collected by Dr. M. R. Smith. The description of the third (?) stage female is of a specimen which Dr. Smith collected on oak at Adaton, April 5, 1927. There is present in this material one young adult female which measures 2.1 mm. in length. All the other specimens collected at this time are immature.

This species is apparently closely related to *jessica* but it differs from that species in possessing distinct anal lobe cerarian spines and larger anal lobe setæ.

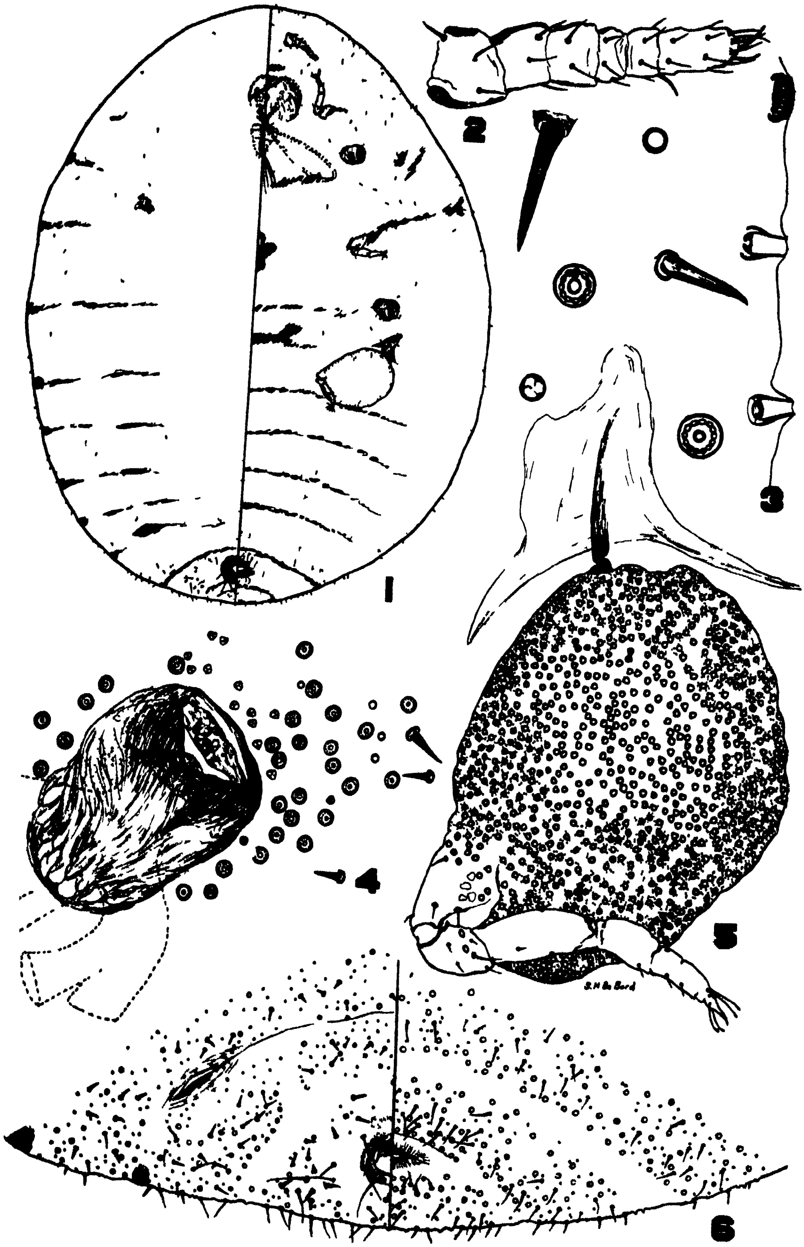
The holotype and paratypes are in the coccoid collection of the Mississippi State Plant Board.

BIBLIOGRAPHY.

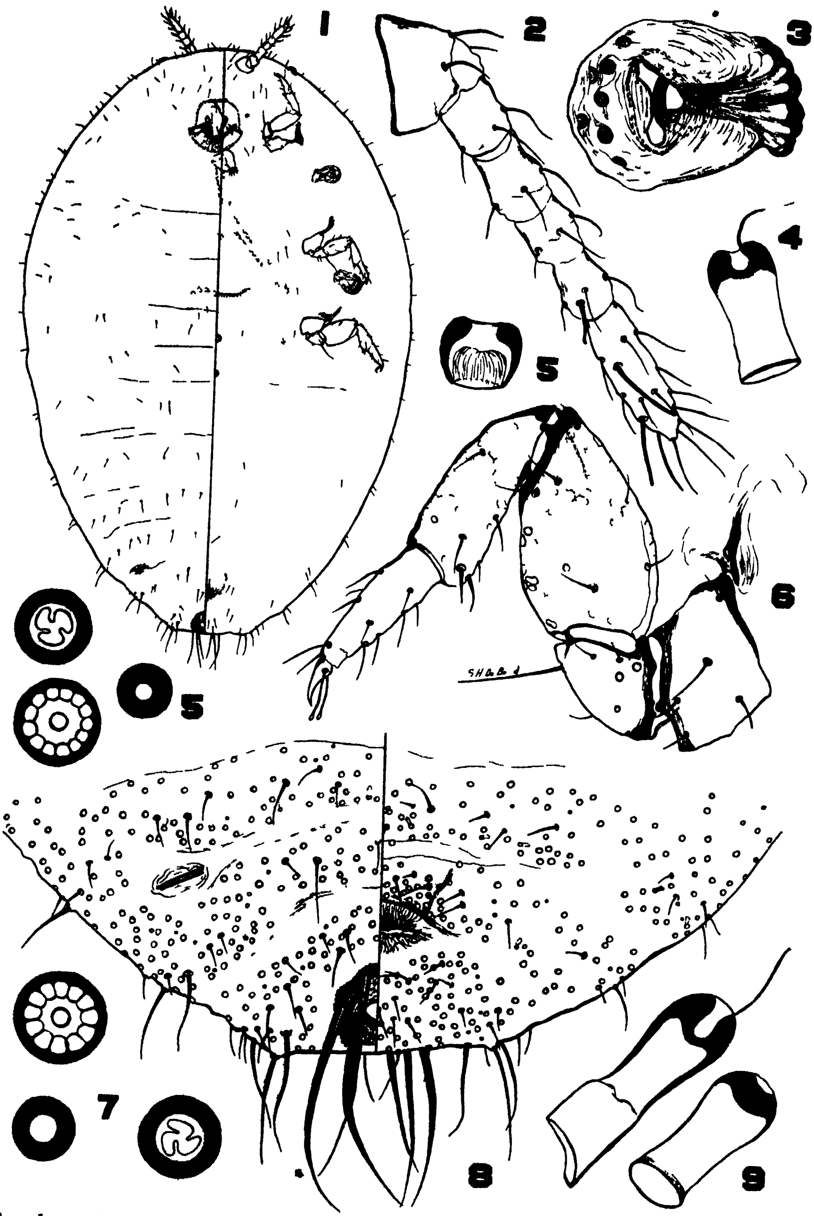
(1) Bull. Ent. Res., XVI, 2, p. 163, 1925.
(2) Ann. Ent. Soc. Amer., XVIII, 4, p. 432, 1925.
(3) Ann. Ent. Soc. Amer. XXII, 2, p. 197, 1929.
(4) Proc. Biol. Soc. Wash., 40, pp. 99–100, June, 1927.
(5) Ann. Ent. Soc. Amer., XXII, 1, p. 33, 1929.
(6) California Species of Mealybugs, Leland Stanford Junior University Publications, 1918.



Phenacoccus insignis, new species. Adult female. 1, Anal ring × 350. 2, Duct and trilocular pore from dorsal surface, × 1100. 3, Duct, ventral surface, × 1100. 4, Anterior spiracle, × 350. 5, Pores, ventral surface near vulva, × 1100. 6, Hind leg, × 118. 7, Posterior end of abdomen, × 69.

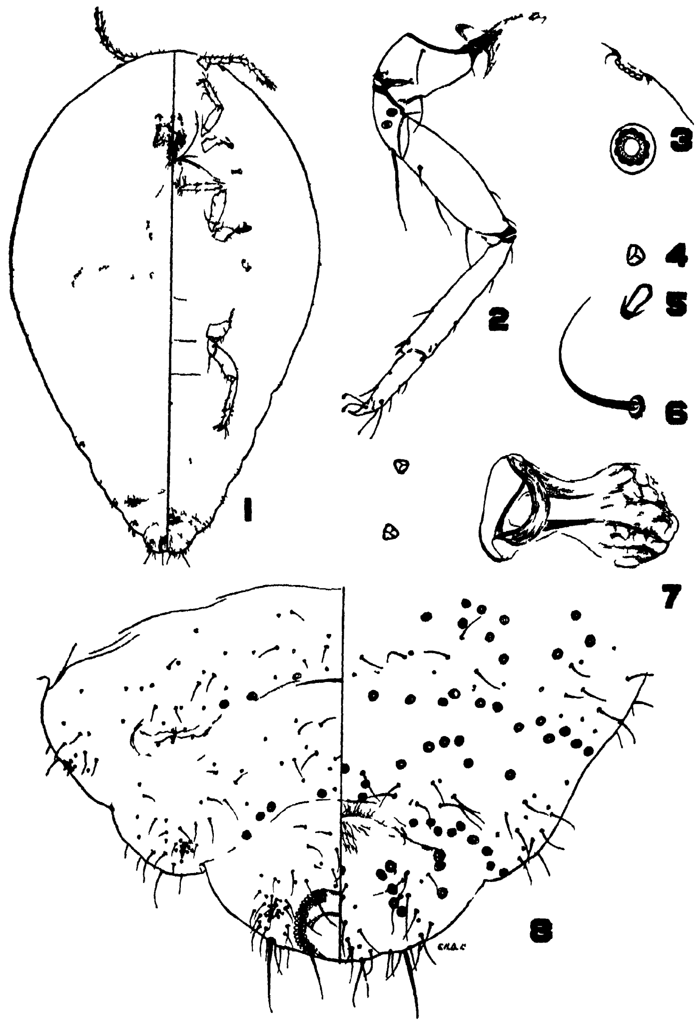


Pseudantonina giganticoxa new species. Adult female. 1, Adult female, × 41. 2, Antenna, × 290. 3, Setæ, pores, ducts, × 875. 4, Posterior spiracle, × 290. 5, Left hind leg, × 290. 6, Posterior abdominal segments, × 94.

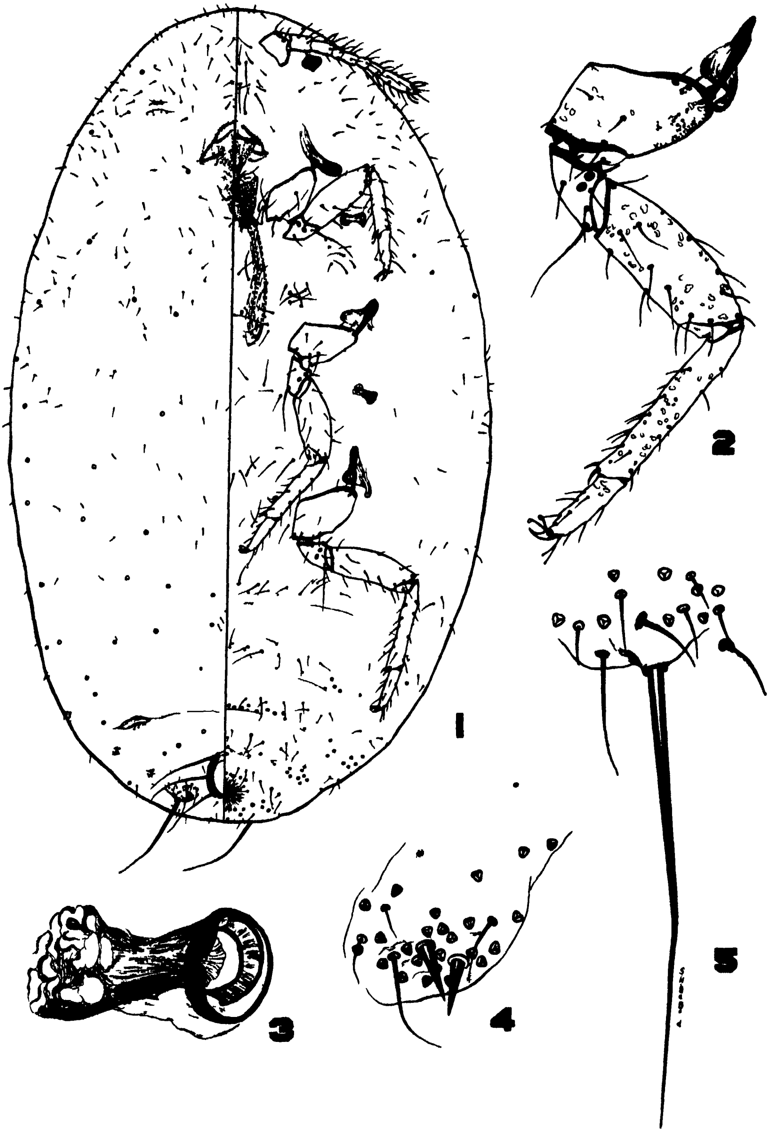


Pseudantonina spirapuncta new species. Adult female. 1, Adult female, × 46. 2, Antenna, × 400. 3, Spiracle, posterior, × 400. 4, Duct of ventral surface, × 1750. 5, Pores of ventral surface, × 1750. 6, Hind leg, × 290. 7, Pores of dorsal surface, × 1750. 8, Posterior end of abdomen, × 152. 9, Ducts of dorsal surface, × 1750.

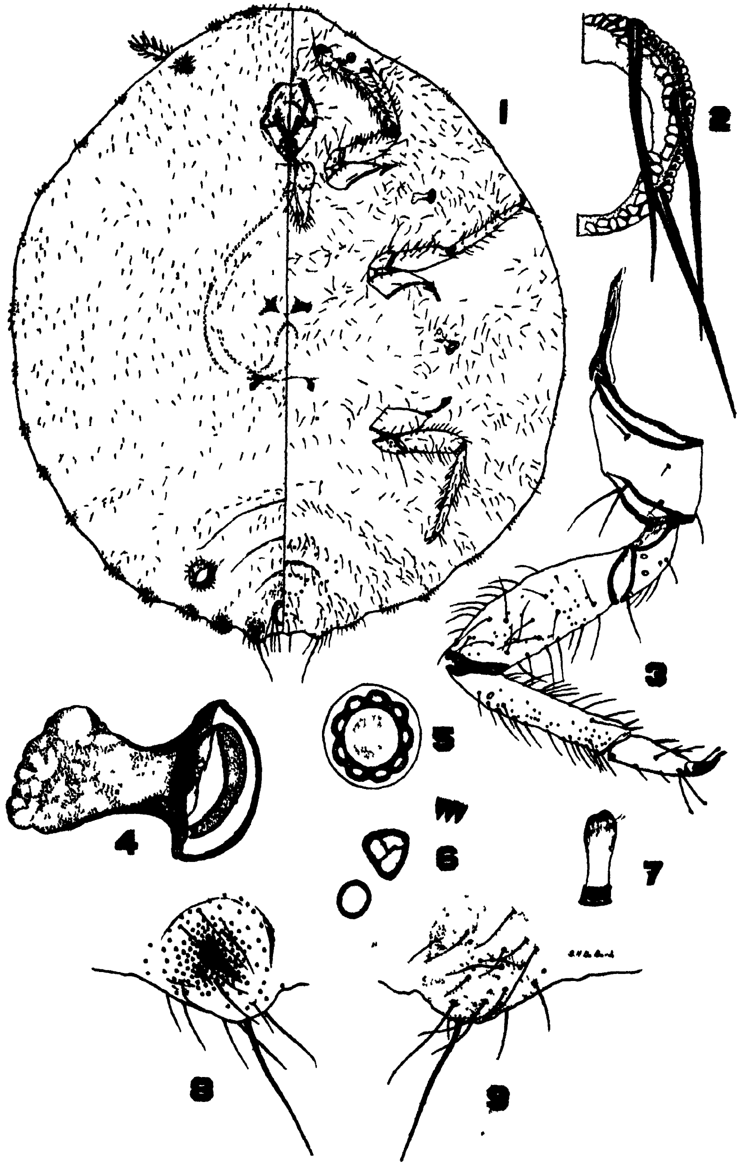
PLATE IV.



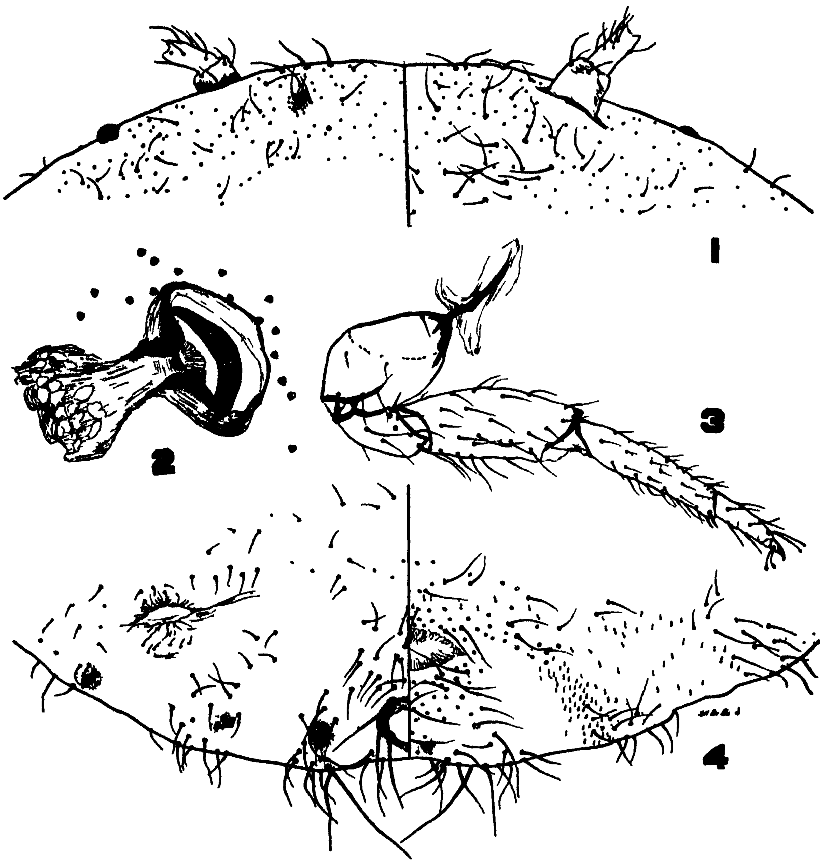
Pseudococcus acutus new species Adult female 1, Adult female, × 34 2, Hind leg, × 152 3, Pore, × 875 4, Trilocular pore, × 875 5, Duct, × 875. 6, Seta, × 875 7, Posterior spiracle and pores, × 225 8, Posterior end of abdomen, × 187.



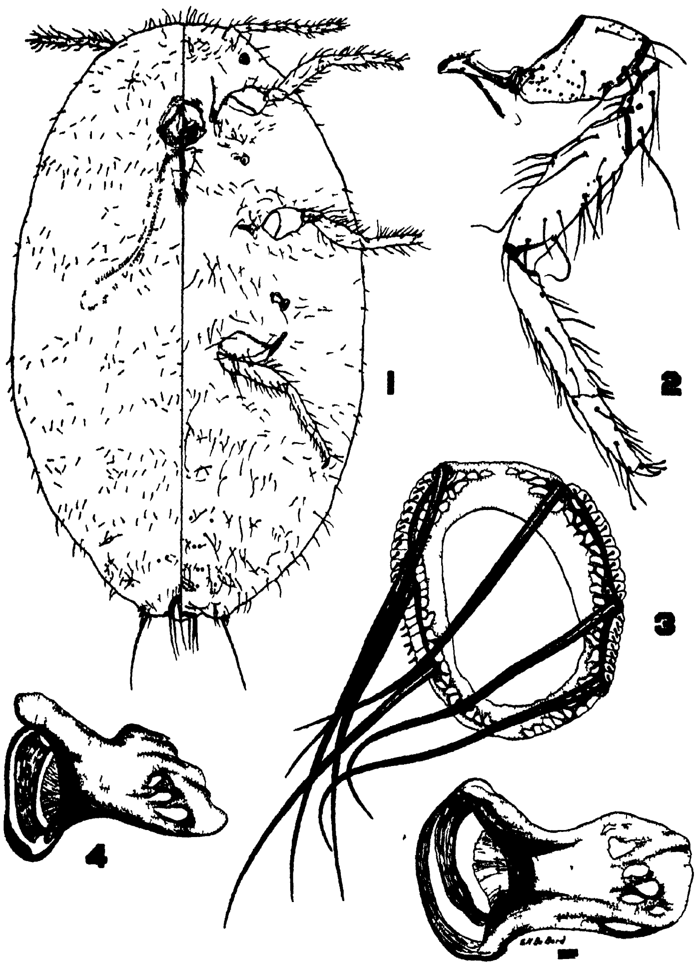
Pseudococcus dentatus new species Adult female. 1, Adult female, × 68 2, Posterior leg, × 152 3, Posterior spiracle, × 725. 4, Anal lobe, dorsal × 400 5, Anal lobe ventral, × 400.



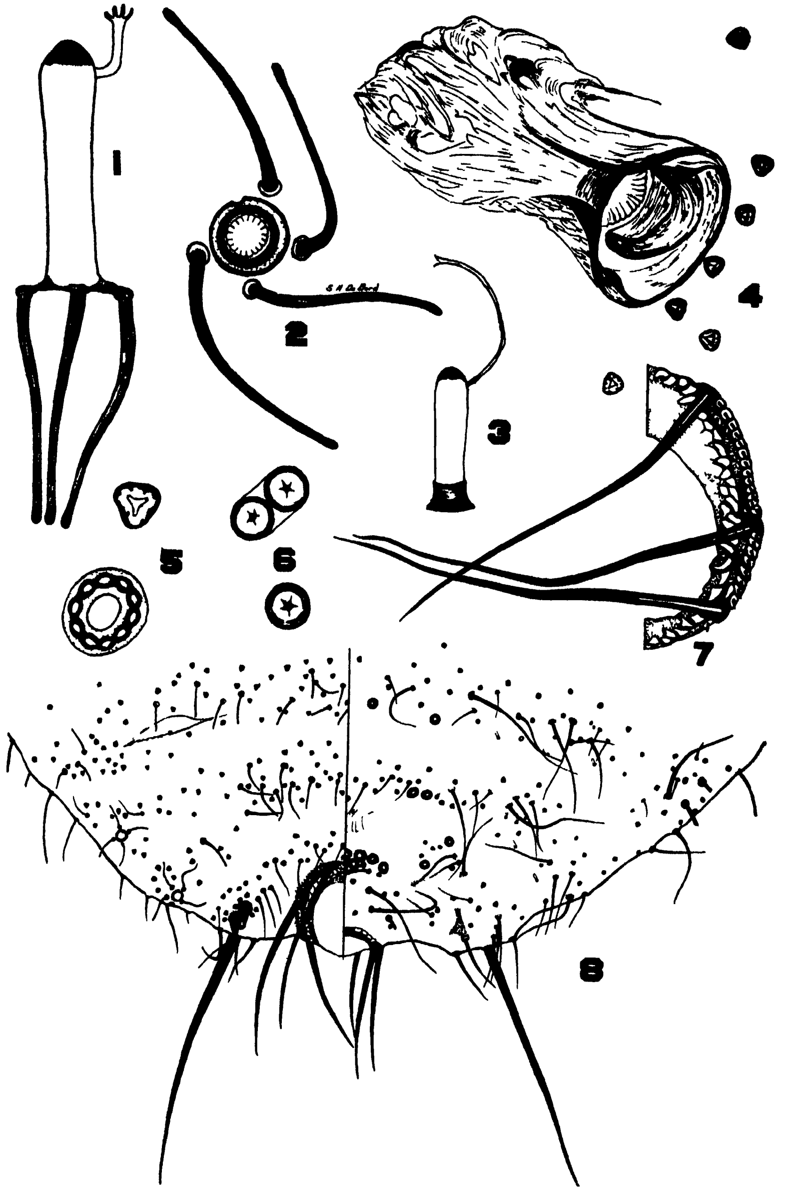
Pseudococcus difficilis new species. Adult female. 1, Adult female, × 40. 2, Anal ring, × 350. 3, Hind leg, × 118. 4, Anterior spiracle, × 350. 5, Multilocular pore of ventral surface, greatly enlarged. 6, Trilocular pore and markings of derm, greatly enlarged. 7, Duct, greatly enlarged. 8, Anal lobe, dorsal aspect, × 203. 9, Anal lobe, ventral aspect, × 203.



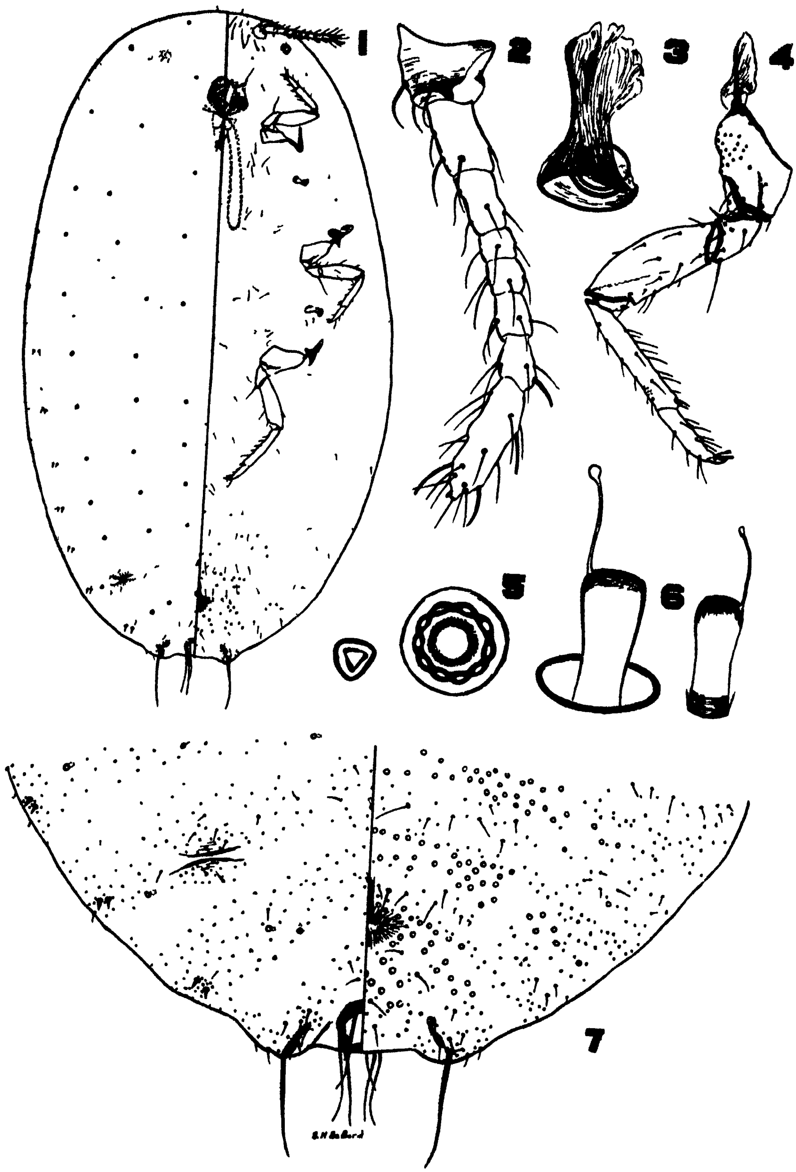
Pseudococcus obesus new species. Adult female. 1, Anterior end of head, × 68. 2, Posterior spiracle and pores, × 290. 3, Hind leg, × 94. 4, Posterior end of abdomen, × 68



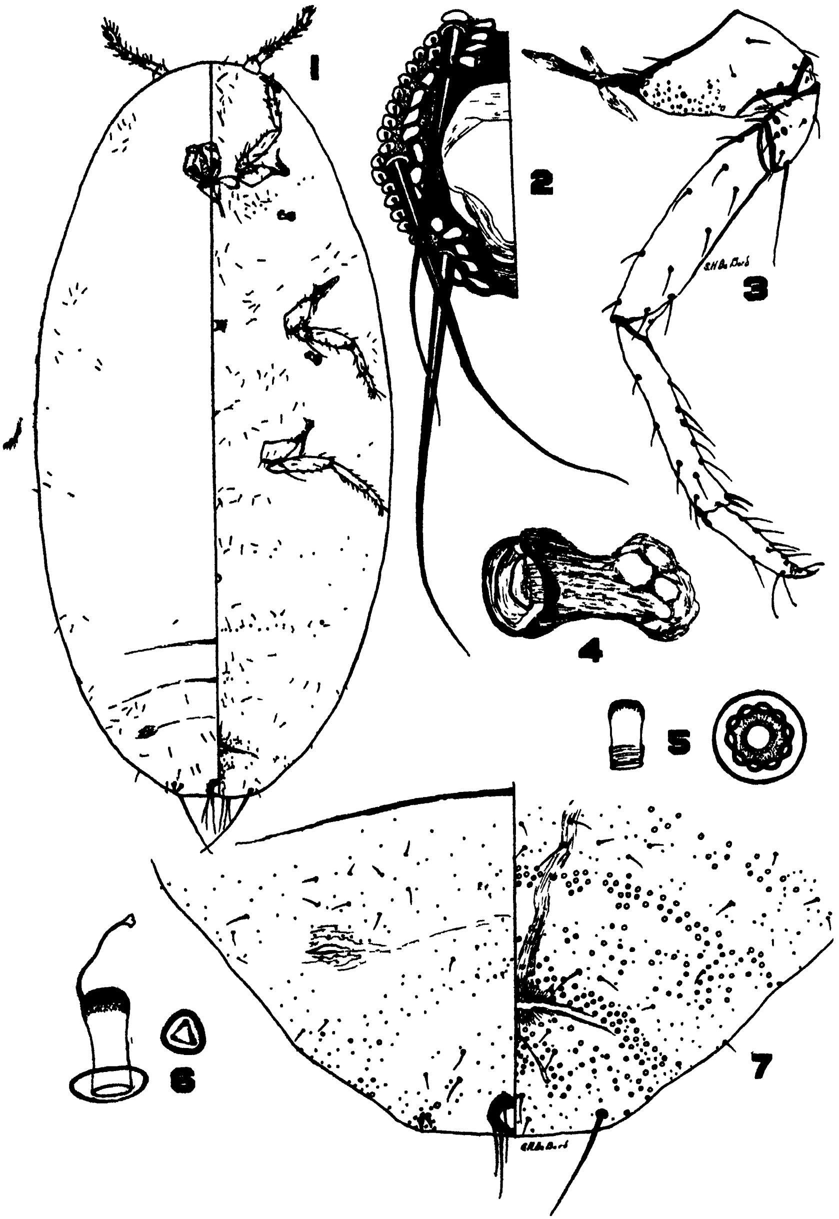
Trionymus claviseta new species. Adult female (see also plate IX) 1, Adult female, × 39 2, Hind leg, × 118. 3, Anal ring, × 350. 4, Anterior spiracle, × 471. 5, Posterior spiracle, × 471



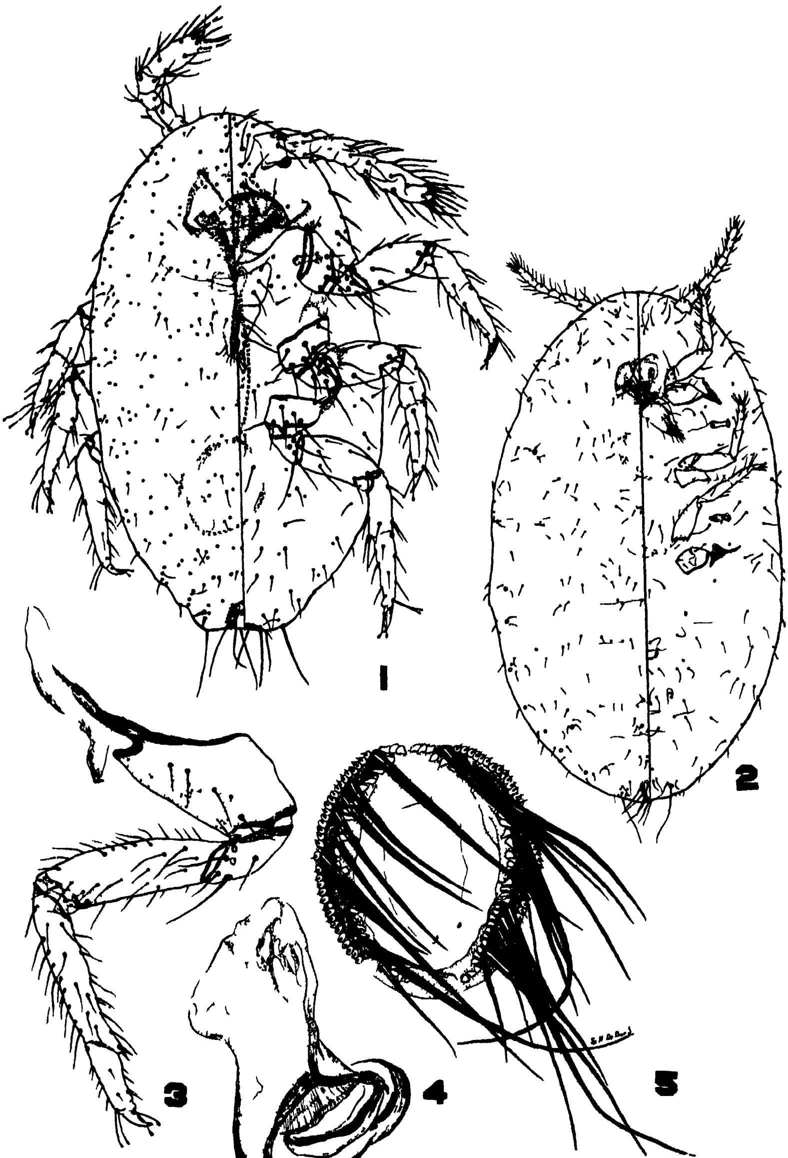
Trionymus claviseta new species Adult female 1, Duct, side aspect, × 1500? 2, Duct, surface aspect, × 1500? 3, Small duct of ventral surface, × 1500? 4, Posterior spiracle and pores, × 750. 5, Pores, × 1500? 6, Pores, × 1500? 7, Anal ring, × 350. 8, Posterior end of abdomen, × 141.



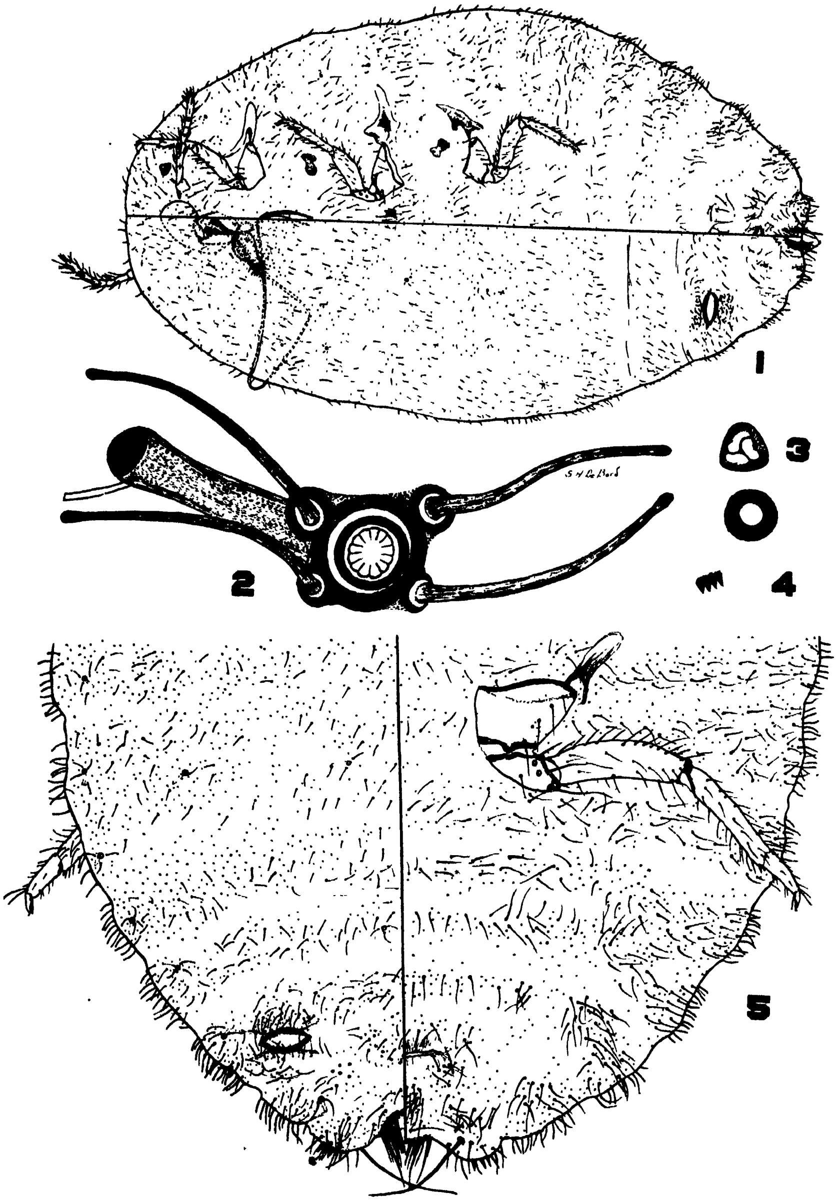
Trionymus mori new species. Adult female. 1, Adult female, × 42. 2, Antenna, × 465. 3, Spiracle, posterior, × 465. 4, Hind leg, × 240. 5, Pores, × 1750. 6, Ducts, × 1750. 7, Posterior end of abdomen, × 100.



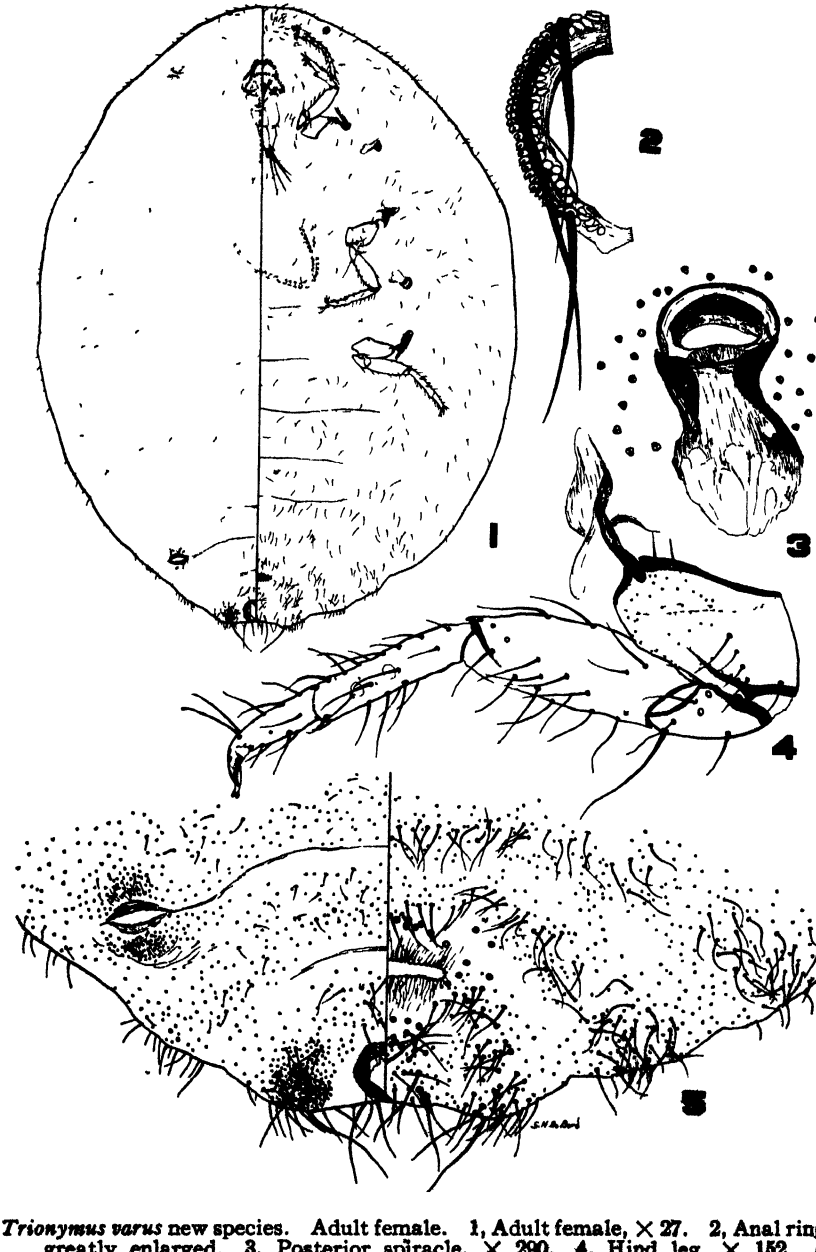
Trionymus rostellum new species. Adult female. 1, Adult female, × 80. 2, Anal ring, × 725. 3, Hind leg, × 187. 4, Posterior spiracle, × 465. 5, Duct and pore of ventral surface, × 1750. 6, Duct and pore of dorsal surface, × 1750. 7, Posterior end of abdomen, × 109.



Trionymus setosus new species Immature. 1, Newly hatched larva, × 118. 2, Second stage, (?), × 48. Adult female. 3, Hind leg, × 76. 4, Anterior spiracle, × 290. 5, Anal ring, × 290.



Trionymus setosus new species. Adult female. 1, Adult female, × 22. 2, Duct, × 972 (?). 3, Trilocular pore, greatly enlarged. 4, Markings of ventral derm, greatly enlarged. 5, Hind leg and abdomen, × 58.



Trionymus varus new species. Adult female. 1, Adult female, × 27. 2, Anal ring, greatly enlarged. 3, Posterior spiracle, × 290. 4, Hind leg, × 152. 5, Posterior end of abdomen, × 77.

THE PLEURAL AND STERNAL SCLERITES OF THE LEPIDOPTEROUS THORAX.*

HAROLD H. SHEPARD,
U. S. Bureau of Entomology, Washington, D. C.

INTRODUCTION.

Some excellent studies have been made by various workers on the morphology of the sclerites of the thorax of insects. Few of these, however, have dealt with the thoracic sclerites of Lepidoptera. Many of the figures of the thorax of Lepidoptera that may be found in our present literature are either very unsatisfactory drawings or are merely included in a general study of all orders of insects with respect to the morphology of this body-region. No American investigator up to now has devoted much study to the different types of development in the lepidopterous thorax.

Because of the evident value of a study of the thoracic sclerites in determining the phylogenetic relationships of the families of insects, this study has been undertaken. In the Lepidoptera there is a somewhat customary linear arrangement of families. When any attempt has been made to derive a phylogenetic tree to show which families are the more primitive and generalized, and which the more specialized, and to show how close the more primitive families may be to the ancient lines of development of which the higher families are the result, there has been considerable disagreement amongst the various arrangements which have been published. A discussion of phylogeny, it seems to the author, should be based upon a careful comparison of many species in each family, in order that there may be no conclusion based upon aberrant forms. Owing to a great lack of information only a few general conclusions concerning phylogenetic relations in the Lepidoptera may be pointed out at this time. At a later date it is hoped

* This paper is offered as a thesis in partial fulfillment of the requirements for the Degree of Doctor of Philosophy at the Massachusetts Agricultural College. The author is indebted to Dr. G. C. Crampton for his suggestion of the subject and for his helpful interest and encouragement, and to Dr. H. T. Fernald for his kind assistance in securing specimens from various sources. He also wishes to express his appreciation of much useful criticism by Mr. R. E. Snodgrass, of the U. S. Bureau of Entomology.

that further study will have gained for us sufficient material to formulate, in conjunction with phylogenetic evidence from the other useful characters, a general family relationship in the Lepidoptera.

GENERAL TERMINOLOGY.

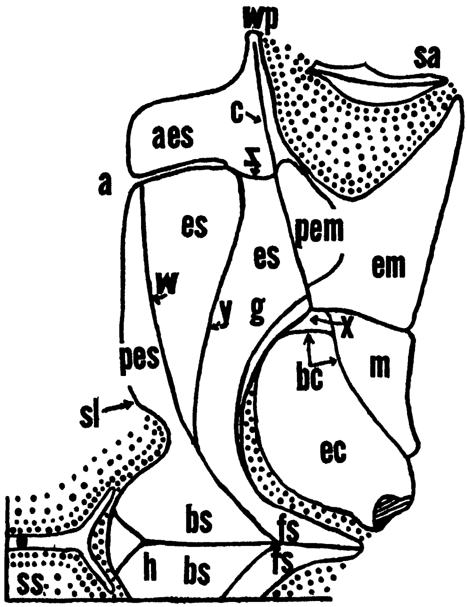
In this discussion two forms will be employed for illustration, namely, *Melittia satyriniformis* Hbn. (Aegeriidæ) (Fig. 1) and *Catocala concumbens* Wlk. (Noctuidæ) (Fig. 2). It is not claimed that the former species is particularly primitive in many respects. The species is used here because it shows in the one insect most features of the pleural region which occur in part in many of the higher families of Lepidoptera. *Catocala concumbens* is representative of the latter. The figure in the text may be referred to for the general relationships of the various features of the lepidopterous mesopleuron and sternum.

The terminology used is that adopted by most of the recent writers on general morphology of the thorax, such as Crampton (1909–1926), Snodgrass (1909–1927), Young (1921), etc. However, certain characteristic sutures and other formations not previously named in the lepidopterous thorax require descriptive terms by which they may be designated in such a paper as this one.

Each typical wing-bearing segment in the Lepidoptera has a *pleural suture* (*c*) (see text figure), traversing the pleural region from the *pleural wing process* (*wp*) to the coxa. The part of the pleuron anterior to the suture and which "always extends from the top to the bottom of the pleural plate" (Crampton, 1914a), is called the *episternum* (*es*) while that posterior to it is the *epimeron* (*em*). Quoting from Young (1921), "The straightness of the pleural and coxal ridges is a mark of primitiveness." While this is a general truth in the case of the pleural suture, it is not strictly so in the two species figured for illustration of these terms. The aegeriid *Melittia satyriniformis* (Fig. 1) has the pleural suture (or "ridge") extremely curved, while *Catocala concumbens* (Fig. 2), in a family considered to be more highly developed in general than the Aegeriidæ, has a pleural suture less curved. However, *M. satyriniformis* may be considered a member of a lower family which has particularly developed so as to bend the pleural ridge out of proportion to the rest of its development.

In this order the basicoxite is enlarged by the distal extension of *the basicostal suture* (*bc*) on the coxa posteriorly to form the large *meron* (*m*), as is the case in the Neuroptera, Mecoptera, Trichoptera, some Diptera, etc. Snodgrass (1927) figures the coxa of *Conopia* (*Aegeria*) *exitiosa* Say and discusses the relationships of the basicoxite. In such

families as the Micropterygidæ (Fig. 5), Hepialidæ (Fig. 6), Megalopygidæ (Fig. 9), Pyromorphidæ (Fig. 18), and Psychidæ (Fig. 16) there is none of the anterior part of the basicoxite visible externally. In *Adela purpura* Wlk. (Fig. 8) and in most of the higher families there is in the angle of the eucoxa between the meron and the pleuron a small sclerite which may be called the *epicoxal piece* (*x*); it is undoubtedly the exposed part of the basicoxite anterior to the pleural articulation of the coxa.



DIAGRAMMATIC STRUCTURE OF THE TYPICAL LEPIDOPTEROUS MESOPLEURON AND STERNUM.

a, anepisternal suture; *aes*, anepisternum; *bc*, basicostal suture; *bs*, basisternite; *c*, pleural suture; *ec*, eucoxa; *em*, epimeron; *es*, episternum; *fs*, furcisternite; *g*, marginopleural suture; *h*, midventral suture; *m*, meron; *pem*, preepimeron; *pes*, preepisternum; *sa*, subalare; *sl*, sternal lobe; *ss*, spinisternite; *w*, preepisternal suture, *wp*, pleural wing process; *x*, epicoxal piece; *y*, precoxal suture; *z*, anepisternal sutural connective.

A typical subdivision of the mesothoracic episternum occurs in the Lepidoptera. A longitudinal suture cuts the episternum of this segment in nearly equal parts, the upper smaller one being the *anepisternum* (*aes*), and the lower the *katepisternum*. The katepisternum is fused to such an extent with the sternal regions and then so divided by secondary sutures that other terms have been found more useful in such orders as the Neuroptera, Mecoptera, Trichoptera, Lepidoptera, etc. The lower region of the episternum together with the sternum is termed the *sternopleurite* (*spl*).

A process is found in many of the more highly developed Lepidoptera, such as the Glyphipterygidæ, Aegeriidæ, Geometridæ, Noctuidæ, Sphingidæ, Saturniidæ, etc , which may be called the *sternal lobe* (*sl*) (see text figure), and is an anterior projection of the lower region of the episternum which overhangs the sternum. It is sometimes very prominent and covers a considerable pocket which extends entirely across the sternal region.

The *anepisternal suture* (*aes*) is a very useful landmark. In very few cases, such as *Thyris maculata*, has it been found lacking. It is usually present as a membranous open cleft (*Episternalspalt*, Weber, 1928), extending from the anterior margin of the episternum about three-quarters of the distance to the pleural suture Sometimes it is closed, the opposite margins of the cleft being drawn together. Sometimes it extends entirely to the pleural suture, but usually the posterior part is only slightly visible as an internal thickening of the exoskeleton. Usually when a connection with the pleural suture is visible, there is a tendency, especially in the higher families, for the *anepisternal sutural connective* (*z*) to migrate down that suture In *M. satyriniformis* the anepisternal sutural connective has migrated to the lower end of the pleural suture.

In *Corydalis cornuta* L. (Neuroptera), (Fig 3) there is a secondary suture extending from the posterior end of the anepisternal suture directly to the midventral suture cutting the sternum into *basisternite* (*bs*) anteriorly and *furcisternite* (*fs*) posteriorly. This suture may be termed the *precoxal suture* (*y*). In many groups of Lepidoptera the anepisternal sutural connective is missing but from the posterior end of the anepisternal suture the precoxal suture curves ventrad, sometimes approaching the region of the sternal lobe, sometimes, on the other hand, migrating toward the coxa or even connecting with the *marginopleural suture* (*g*) In the Geometridæ (Figs. 30 and 31) a curious thing apparently happens to this suture. The pleural suture is very deeply inrolled and the episternum is drawn in so far that the precoxal suture is hidden for a distance therein, the lower part arising from the pleural suture just above the origin of the marginopleural suture.

From a point near the anterior end of the anepisternal suture the *preepisternal suture* (*w*) extends ventrally to the sternal lobe to join the precoxal suture. The region anterior to the preepisternal suture is the *preepisternum* (*pes*) (Crampton, 1914b). In Figure 1 it is seen that the preepisternal suture is slightly demarked, while in the Noctuidæ (Fig. 2) it is very prominent and extends entirely to the anepisternal suture.

In some Zygaenoidea and Pyralidoidea there is a tendency for the anterior part of the mesothoracic epimeron included in the bend of the pleural suture to be marked off from the main part of the epimeron by a more or less distinct furrow or suture. In the Geometridæ there is a greater demarkation of this small anterior region, although the separation is usually very incomplete. In the Noctuidæ and related families, and in the Sphingidæ, a heavy suture, sometimes nearly as prominent

as the pleural suture, marks off this anterior part, which may be appropriately termed the *preepimeron* (*pem*) (Fig. 2). Sometimes another demarkation of the epimeron occurs in which a line extends dorsad from its lower margin. It usually becomes a furrow parallel to the subalar membrane posteriorly (Fig. 1).

In the metathorax of Lepidoptera there is the development of a truly lepidopterous structure at the base of the wings on the dorsal margin of the episternum. In *Micropteryx aruncella* Scop. (Fig. 5) there is a slender vertical projection parallel to the wing process and directly anterior to it which is probably homologous with the *posterior basalare* of Crampton's typical thoracic segment (1914a). Snodgrass (1927) figures a similar structure in *Psocus*. This basalar plate is connected with the episternum at the base of the wing process and apparently is developed in some Lepidoptera to assist that process in supporting the hind-wings. Anterior to the base of the posterior basalare in *Micropteryx* is a small posteriorly curved lobe. This becomes in *Hepialus* (Fig. 6) a much enlarged flap-like projection from the episternum anterior to the wing-base. In slightly more advanced groups such as the Incurvariidæ (Adelidæ) (Fig 8), the *anterior basalare* (or *basalar pad*, *ba*, as it may be called in the Lepidoptera) is fully developed as a cushion-like swelling, not thick-walled as are the surrounding regions but delicate and often covered with short setæ. In Figure 1, showing *Melittia satyriniformis*, the basalar pad is not so clearly demarked as is usual. This appearance may be that which would be found in a stage between *Micropteryx* (Fig. 5) and *Adela* (Fig. 8) in its development.

A line which sometimes appears in the metathoracic episternum may be called the *metepisternal suture*. It usually arises from a slight dorsad angulation of the marginopleural suture.

The epicoxal piece is usually visible in the metathorax, if it is so in the mesothorax.

NOTES ON THE MORPHOLOGY OF THE PLEURAL AND STERNAL REGIONS OF THE MESOTHORAX AND METATHORAX IN THE LEPIDOPTERA AND ALLIED GROUPS.

The following notes are arranged, for the most part, by families in the order that W. T. M. Forbes follows in "The Lepidoptera of New York and Neighboring States" (1923), and in "A List of the Insects of New York" (1926), since these are the most recent works of this type in general use. The figures in many cases show both the pleural and sternal regions of the mesothorax; other figures show only the lateral view as seen without turning the insect.

Order **Neuroptera.**

The lateral view of the thorax of *Corydalis cornuta* L. has been figured by Crampton (1909 and 1914a). Weber (1924 and 1928) has studied the thorax of *Sialis*, giving many extremely useful figures of the exoskeleton and the musculature. As *C. cornuta* is a conveniently large species to show the details of the neuropterous type, the mesothoracic view is figured again (Fig. 3) in this paper. Important details to be noted are:

1. A small button-like sclerite, the forerunner of the *tegula* (*t*) which is applied about the base of the wing anteriorly in Lepidoptera.
2. The straightness of the pleural suture, its lower end forming the lateral condyle upon which the coxa hinges; and the distal extension of the basicostal suture which divides the first joint of the leg into meron and eucoxa as is also the case in the Trichoptera and Lepidoptera.
3. The prominence of the anepisternal suture or cleft. This character is also strongly developed in the Trichoptera and Lepidoptera.
4. The *precoxal suture* (*y*) divides the sternal region into a *basisternite* (*bs*) anteriorly and a *furcisternite* (*fs*) which lies between the coxæ.
5. The sclerites extending ventrad from the region of the trochantin across a large membranous area to the coxa anteriorly continue in such Trichoptera as *Neuronia* (Fig. 4), but seem to be lost, or hidden by infolding or thickening of membranous areas, in the Lepidoptera. In *Phassus* (Fig. 6) and *Micropteryx* (Fig. 5) of the Jugate Lepidoptera the prominent membranous areas separating the coxæ from the pleural and sternal sclerites are very much like those found in *Corydalis* in the Neuroptera and to less extent, and mainly in the mesothorax, in *Neuronia* in the Trichoptera.

Order **Trichoptera.**

Neuronia (Fig. 4) is used to represent the Trichoptera. It is not taken as a primitive species but because it shows characteristics indicating the relationship existing between Trichoptera and Lepidoptera. These may be thought of as characteristics retained in common by both Lepidoptera and Trichoptera from an ancestor perhaps more neuropterous than otherwise. The conception given by Tillyard (1919) is much the idea intended.

1. In *Neuronia* the prothorax is in many ways like that of a lepidopteron. The patagial forerunner is present as a broad plate bearing a slightly elevated wart-like area anteriorly, having in this regard much similarity to *Phassus* and *Micropteryx*. The lateropleurite of the prothorax passes under the anterior part of the patagial sclerite as in such moths as *Prionoxystus* (Fig. 21) and *Thyridopteryx* (Fig. 16).

2. In the mesothorax the anepisternal suture is situated considerably ventrad. The precoxal suture is very distinct and passes from the inner end of the anepisternal suture to a point anterior to the coxa. The anepisternal sutural connective is also very distinct and complete.

3. In the metathorax is a large sclerite at the base of the pleural wing-process, from which the episternal part of that growth arises. It is undoubtedly from a similar division of the metathorax that the basalar pad (anterior basalare) is formed. Below this sclerite other divisions appear which show distinct relation to those in the episternum of *Micropteryx* and *Eriocrania* of the jugate Lepidoptera. In the frenate Lepidoptera it is very difficult to trace the same relationships. From these observations it will be seen that here is but another evidence of the closeness of the Jugatæ to their trichopterous cousins, and that the frenate Lepidoptera are considerably removed from them on other lines of development.

Hermann Weber (1924) figures the lateral view of the thorax of *Psychomia.* The latter is very similar to that of *Neuronia* shown in this paper. Crampton (1920) figures a lateral view of the thorax of *Philopotamus distinctus* Wlk.

Order **Lepidoptera.**

Suborder **Jugatæ.**

Micropteryx aruncella Scop. (*sepella* Fab.) (Micropterygidæ) (Fig. 5) shows certain characters in the lateral view of the thorax which would indicate a secondary division of the mesothoracic epimeron into upper and lower regions in the jugate Lepidoptera. This division is also indicated in *Eriocrania auricyanea* Wlsm. (not figured here but shown in the lateral view in the paper by Crampton, 1920) and less so in *Phassus huebneri* Geyer (Hepialidæ) (Fig. 6).

The tegula at the base of the fore-wing is slightly developed in both *Micropteryx* and the trichopteron *Neuronia.* It is perhaps a little more highly developed in the hepialid *Phassus,* where it is a membranous pad which surrounds the base of the wing as does the thicker-walled tegula in the higher families of Lepidoptera.

Suborder **Frenatæ.**

Incurvarioidea:

Two members of the family Incurvariidæ have been studied, *Tegeticula yuccasella* Riley (Fig. 7) and *Adela purpura* Wlk (Fig. 8). They present a very distinct family character in the mesopleural region,

namely, a triangular sclerite next the pleural suture and on the dorsal side of the marginopleural suture.

It is in the Incurvariidæ that for the first time a greater share of the characteristics are displayed which are found in the secondary divisions of the thorax of the higher Lepidoptera. The figure of *Tegeticula* shows the typical lepidopterous sternum. The sternopleurite of *Corydalis* (Fig. 3) is a wide unbroken plate. In *Tegeticula* (Fig. 7) a membranous gap in it has appeared extending to the precoxal suture. The sternal division is bounded by a sharply defined margin while the pleural is more or less indistinct and becoming lobe-like, tendencies which become more and more pronounced in higher families. The furcisternum is moderately wide in *Tegeticula* but becomes narrow to entirely disappearing in other families.

Zygaenoidea:

Three families are included in this group, two of which are represented by *Megalopyge crispata* Pack. (Megalopygidæ) (Fig. 9) and *Cnidocampa flavescens* Wlk. (Eucleidæ) (Fig. 10), figured in this paper. *Harrisina americana* Guerin (Pyromorphidæ) has also been examined.

These species show a decided tendency toward formation of a preepimeron although in no case has this plate been found to be defined by more than a shallow furrow or an abbreviated suture.

In the Megalopygidæ and Pyromorphidæ the precoxal suture is bent toward the pleural suture to such an extent that it is in part enveloped in that groove. In the eucleid *Cnidocampa*, however, this is not the case. There is in the latter species a triangular sclerite very similar to that which characterizes the Incurvariidæ.

Tineoidea:

Three families in this group have been studied, the species that have been taken to represent them being *Tineola bisselliella* Hummel (Tineidæ) (Fig. 13), *Thyridopteryx ephemeraeformis* Haw. (Psychidæ) (Fig. 16), and *Lithocolletis* sp. (Gracilariidæ) (Fig. 15).

In this group the *spinisternite* (*ss*) is found to be well developed. H. Weber (1924) gives a full page of drawings of the sterna of *Sialis, Psychomyia, Hepialis, Zygaena,* and *Papilio;* and shows the manner in which the prothoracic sternites are progressively developed as the various types are considered. He found that the spinisternite was not developed in *Hepialis* but appeared in the frenate families which he studied. Amongst those species studied in the course of the present investigation, *Tineola* has the posterior fork-like part of the spinisternite* of the prothorax surrounded by a less heavy-walled area which occupies a considerable space anterior to the basisternum of the mesothorax.

In both *Tineola* and *Lithocolletis* the furcisternite is rather broad, but in *Thyridopteryx* it is very narrow and hidden.

* In all cases in which the spinisternite is mentioned in this paper reference is made to the part of it (sometimes entirely separated) posterior to the spina which is more or less closely associated with the basisternite of the mesothorax in Lepidoptera. In general the prothorax is not discussed in this paper.

Thyridopteryx has the spinisternite produced on each side laterally as an arc the inner margin of which near the tip is fastened to the margin of the sternum posterior to it.

Lithocolletis has taken a course of development opposite to that of *Tineola* in that the anterior part of the pleuron between the anepisternum and the sternum has become membranous over an area extending halfway to the pleural suture.

Cycnodioidea (Elachistoidea):

One species has been studied in this superfamily, viz., *Aphelosetia* sp. (Cycnodiidæ) (Fig. 12). It will be seen by comparing the figures that this species is much like *Lithocolletis* (Fig. 15) in the demarkation of the mesopleuron and mesosternum. The antero-lateral areas are more thickly walled and the precoxal suture does not meet the pleural suture.

Gelechioidea:

Following the tendencies previously noted for the Zygaenoidea, the members of the gelechioid families, and especially the Gelechiidæ, show a still more complete separation of a preepimeron from the epimeron of the mesothorax. This is in direct contrast to the lack of any such division in the Tineoidea and Cycnodioidea.

Depressaria atrodorsella Clem. (Oecophoridæ) (not figured) shows the precoxal suture meeting the anepisternal suture at its posterior end; *Ypsolophus ligullelus* Hbn. (Gelechiidæ) (not figured) shows those sutures nearly in junction at that point; whereas in the only species figured in this group, *Phthorimaea operculella* Zell. (Gelechiidæ) (Fig. 19) the precoxal suture is but slightly developed.

Yponomeutoidea:

Species studied and figured are *Atteva punctella* Cram. (Yponomeutidæ) (Fig. 17) and *Simaethis pariana* Clerck (Glyphipterygidæ) (Fig. 14). *Melittia satyriniformis* Hbn. (Aegeriidæ) (Fig. 1), discussed in the first part of this paper, belongs to this group.

The outstanding features of the mesopleuron and the sternum of this group are: 1. The projection of the sternal lobe ventrally from the partially demarked preepisternum. 2. The preepimeron slightly or but partially defined. 3. The demarkation, at least in *Atteva* and *Simaethis*, of a narrow presternum along the anterior margin of the sternum.

Tortricoidea:

Very few species in this group have been examined. Some further study and comparison of the various types within the families will be of interest and applicable in fixing the family characteristics. *Carpocapsa pomonella* L. (Fig. 23) and *Archips* sp. (Fig. 11) are representative of two of the subdivisions of the Tortricidæ, while *Prionoxystus robiniæ* Peck (Fig. 21) has been taken to represent the Cossidæ.

All three species show many characters in common, both in the mesopleura and in the metapleura. Only in *Carpocapsa* is the meso-

thoracic preepimeron at all defined and even here it is still partially connected with the rest of the epimeron. In *Archips* the region of the sternal lobe is entirely membranized, in *Prionoxystus* that region is rather flat and illy defined, while in *Carpocapsa* it appears as a rather low but distinctly-formed lobe. There is also a marked difference in the three species as to the position of the precoxal suture as may be seen by reference to the figures of the respective species. It will be noticed that *Archips* has a very decided similarity to the tineoid *Lithocolletis* (Fig. 15) in respect to the mesothoracic pleuron and sternum.

Pyralidoidea:

Aside from *Thyris maculata* Harr. (Thyrididæ) (Fig. 20), the studies in this group have been entirely amongst the various subfamilies of Pyralididæ, namely *Galleria mellonella* L. (Galleriinæ) (Fig. 24), *Desmia funeralis* Hbn (Pyraustinæ) (Fig. 22), *Crambus* sp. (Crambinæ) (Fig. 25), and *Ephestia kuehniella* Zell. (Phycitinæ) (Fig. 26).

In the mesothorax of *Thyris* is seen a remarkable development of that suture which defines the preepimeron, and still more noticeable, the entire loss of the anepisternal suture and the formation of two very long narrow branches of the prothoracic spinisternite which extend separately nearly or quite to the spina. The sternal lobe seems to have become flattened out and resembles, at least superficially, a condition in the Papilionoidea where the preepisternum does not tend to overhang a part of the sternum.

The Pyralididæ examined show a highly developed sternal lobe, bending ventrad to cover parts of the mesosternum. There is a characteristic forking of the marginopleural suture of the mesopleuron, both forks nearly or quite reaching the pleural suture. The latter character is also true of *Thyris*. The pleural suture is slightly bent in all species.

Saturnoidea:

Automeris io Fabr. (Saturniidæ) (Fig. 28) presents a rather simple pleural map. The sternal lobe has a sharp deep pocket beneath it. The suture marking off the preepisternum is very distinct and extends to the anepisternal suture near its anterior end, a character also found in *Anisota senatoria* S. & A. (Citheroniidæ) (Fig. 38).

Bombycoidea:

Bombyx mori L. (Bombycidæ) (Fig. 27) is in general similar to *Automeris*.

Malacosoma americana Fabr. (Lasiocampidæ) (Fig. 29) does not have the preepisternum demarked and the sternal lobe is broader.

Apatelodes torrefacta S. & A. (Eupterotidæ) (Fig. 35) has the anepisternum of the mesothorax very much swollen. The spinisternite is narrow, the ends of the obtuse fork joined to the sternum posterior to it. The preepisternal suture meets the anepisternal cleft some little distance from the opening of the latter. As in the other species of Bombycoidea and those also of Saturnoidea that were studied there is no preepimeron.

Drepanoidea:

Oreta irrorata Pack. (Drepanidæ) (Fig. 32) has no sternal lobe; the precoxal and marginopleural sutures are prominent, and likewise the ventral half of the preepisternal suture. The preepimeron is moderately defined. The part of the pleural suture between the wing-process and the preepimeron is rolled over the episternum so that two layers of the body-wall are covered by the membranous area below the wing.

Geometroidea:

Brephos infans Moeschler (Brephinæ) (Fig. 31) and three species of Geometrinæ (*Erannis tiliria* Harr., Fig. 30; *Ectropis crepuscularia* D. & S.; and *Abbottana clemataria* S. & A.) have the upper part of the pleural suture hidden as in the Drepanidæ. The sternal lobe is absent or not prominent, the preepimeron is not strongly demarked, and the precoxal suture is not present in the Geometroidea examined. The preepisternal suture is very short, extending only about a third of the distance from the coxa toward the anepisternum. The prothoracic spinisternite is acutely forked with the branches narrow, whereas in the Saturnoidea it is obtusely forked.

In the Geometrinæ the spinisternite is joined to the basisternite which is only moderately arched cephalad. In *Brephos infans* (Brephinæ), however, it is free, the anterior margin of the basisternite very acute and extending some distance cephalad between its branches. It is characteristic of this forked type of spinisternite that the branches approach or are joined posteriorly to the basisternite at a point very close to the furrow beneath the sternal lobe.

Sphingoidea:

Sphinx gordius Stoll (Fig. 33), *Amphion nessus* Cram. (Fig. 48), and *Phlegethontius sexta* Joh. have moderately produced sternal lobes and definite preepisterna in the mesothorax, much as in *Carpocapsa* (Tortricidæ). The preepimeron is completely and markedly separated from the rest of the epimeron, the upper end of it produced dorsad and lying in a cavity over the pleural suture. This cavity extends into the anepisternum dorsally. In *Amphion* the branches of the spinisternite are lanceolate with a very narrow juncture at the midventral line.

Noctuoidea:

The members of this group must be very closely related to the Sphingoidea, judging by the lateral aspect of the thorax. The greatest differences lie in the shape of the spinisternite which, however, seems to vary in form between allied genera or groups of genera. In all the families the preepimeron is particularly well developed and the preepisternal suture reaches nearly or quite to the anepisternal suture.

In the Notodontidæ, *Melalopha inclusa* Hbn. (Fig. 39) and *Datana ministra* Drury (Fig. 37) have been examined. *Melalopha* has the preepisternum considerably enlarged and lying over a part of the sternum; the preepisternal suture is rather short and has migrated toward the pleural suture. The narrow branches of the prothoracic

spinisternite extend very far cephalad before uniting. *Datana* is very similar to the typical noctuid in the fact that the preepisternal suture extends to the anepisternal cleft. The spinisternite is narrow and acute but not as much so as in the previous species; it is joined to the basisternite of the mesosternum.

The Liparidæ which were studied (*Hemerocampa leucostigma* S. & A. (Fig. 40) and *Stilpnotia salicis* L.) have the membranous subalar region extending well down toward the meron of the coxa. In *Hemerocampa* the preepisternal suture extends in a nearly straight line to a point close to the anepisternal suture. The spinisternite is narrow and somewhat acutely angled

Members of various subfamilies of the Noctuidæ have been examined. In general they are very similar and much like *Datana* of the Notodontidæ. The precoxal suture appears as a more or less well-defined line in most of the species. An undetermined species of Hypeninæ has the branches of the spinisternite attached broadly to the basisternite; the preepimeron is nearly round. *Alabama argillacea* Hbn. (Erebinæ) has an extremely acutely branched spinisternite and the sternal lobe overhangs the sternum as it does in *Melalopha* (Notodontidæ). The anepisternum of *Autographa falcigera* Kirby (Plusiinæ) (Fig 43) extends farther ventrad than usual. In *A. basigera* Wlk. the precoxal suture bends cephalad not more than halfway to the preepisternal suture instead of joining with it as in *A. falcigera;* both species have the spinisternite joined to the basisternite. *Zale undularis* Drury and *Catocala concumbens* Wlk. (Fig. 2), both Catocalinæ, resemble each other closely; the spinisternite is typically joined; the species are alike in having the precoxal suture visible for only a short distance *Lithacodia carneola* Gn. (Erastriinæ) is very similar to the previous group. *Pyrophila pyramidoides* Gn. and *Septis arctica* Lef. (Fig. 34) of the Acronyctinæ are very much alike; moreover *Eucirrhoedia pampina* Gn. (Cuculliinæ) has almost exactly the same thoracic pleural map as has *Pyrophila.* Of the Agrotinæ, *Lygranthoecia marginata* Haw. (Fig. 36), *Feltia subgothica* Haw., *Lycophotia margaritosa* Haw., *Matuta prasina* Fabr., and *Heliothis obsoleta* Fabr. have been examined. In general the spinisternite is obtusely forked, thus differing from the acute forking in most of the Noctuidæ. In *Lycophotia* the spinisternite differs from the other Agrotinæ that have been studied in that it bears a midventral suture like that which is present in the sternum proper.

The Arctiidæ possess the same general characteristics in the regions under discussion as do the Agrotinæ, the only differences worth mentioning here belonging to the sternum In *Utetheisa bella* L. the obtusely forked spinisternite is broadly attached to the basisternite, possibly somewhat farther from the sternal lobe than is the usual case in the Noctuidæ. *Isia isabella* S. & A. is very similar but with a broader preepisternum and with the arms of the spinisternite more slender and straight, and not attached to the basisternite. The spinisternite of *Estigmene acraea* Drury (Fig. 41 and 41A) is very different from that of all the other Noctuoidea examined in that it is joined to the basisternite less than half the distance from the midventral line to the sternal lobe, and only encloses a very small heart-shaped membranous area.

Nola ovilla Grote (Nolidæ) has characters which are similar to those of the following species, namely, lack or modification of the preepimeron, shortness of the preepisternal suture, etc. The spinisternite, however, is very narrow and with very short acutely angled arms, not diverging much from the midline; it is not like that of any of the other Noctuoidea.

Scepsis fulvicollis Hbn. (Euchromiidæ) (Fig. 42) has the spinisternite very broadly forked and as a consequence a rather narrow area between it and the anterior margin of the basisternite.

Hesperioidea:

In *Epargyreus tityrus* Fabr. (Pyrginæ), (Fig. 44) the anepisternum although clearly differentiated is smaller than in the specialized families just discussed. There is no preepimeron; the spinisternite is not fork-like although it retains its two posterior arms which do not extend far from the midventral line, the remaining space being enroached upon by the preepisternum; the latter region is diminishing dorsally. *Pyrgus tessellata* Scudd. (Pyrginæ) differs in having the anepisternum much less heavily walled than the regions below it, and a narrower spinisternite as in *Polites*.

Polites peckius Kirby (Hesperiinæ) shows a very significant variation from the pleural map of *Epargyreus* (Fig. 44). The anepisternum is still more reduced, and most of it is covered by the tegula, that part being membranous. The spinisternite has longer narrow pointed arms which lie in angles between the basisternite and the preepisterna.

The spinisternite of *Goniurus proteus* L. (Pyrginæ) is forked more as in *Polites* (Hesperiinæ), so the reduced spinisternite of *Epargyreus* is not typical of the Pyrginæ, although it is an interesting type rather similar to that of *Danaus* (Nymphalidæ) and of *Papilio* (Papilionidæ). This is another example of the variability of form of the spinisternite in rather closely allied groups of genera.

Papilionoidea:

Heodes hypophlaeas Edw. (Lycaenidæ), (Fig. 45) shows a very great resemblance to the other butterflies in the characters under discussion, while the Hesperiidæ which were examined show very little change in characters from those of the various generalized Lepidoptera studied. There is here then a considerable gap in the phylogeny of the Lepidoptera. *Heodes* is remarkable in that the anepisternum has very nearly disappeared, the preepimeron is preserved (in this matter unlike the Hesperiidæ), the precoxal suture connects with the anterior margin of the basisternite, and the preepisternum has become enlarged anteriorly between the spinisternite and the episternum. The spinisternite is long, narrow, and with a short acute fork near the midline. *Incisalia augustus* Kirby is nearly identical with *Heodes* in these characters; the spinisternite, however, has a much broader and less acutely angled fork.

In *Danaus archippus* (Auct.), (Nymphalidæ), (Fig. 50) any vestiges of the anepisternum which remain must be separated from the episternum proper and located close to the wing base. The precoxal suture resembles that of *Heodes* in emerging from the pleural suture

nearly at right angles to it a short distance dorsad of the coxa. The preepisternum is narrow and extends entirely to the wing process; its ventral end is enlarged near the spinisternite. The latter sclerite is shield-shaped with two short arms projecting caudad; it lies for two-thirds its length in a pocket formed by the enlarged ends of the pre-episterna.

An examination of other nymphalid species, such as *Cissia eurytus* Fabr., *Cercyonis alope* Fabr. (Fig. 49), *Argynnis* sp., *Phyciodes tharos* Drury, *Aglais antiopa* L., and *Vanessa cardui* L., shows very little difference amongst the various subfamilies. The precoxal suture is often only partially visible and may arise at different angles. The spinisternite is always much longer and more slender than in *Danaus*, although in general the fork lies in a pocket in the same manner as in that species. In the satyrids *Cercyonis* and *Cissia* there is no pre-episternal suture.

The Papilionidæ and Pieridæ show another development from the lycaenid type. *Papilio glaucus turnus* L. (Fig 46) has a single broad sternopleural plate extending from the midventral line to the pleural suture and the vestigial anepisternum. The precoxal suture has disappeared and the sternopleural plate has broadened anteriorly. The pierids *Pieris rapæ* L., *Eurymus philodice* Godt. (Fig. 47), and *Eurema* sp. likewise show these characters. *Papilio* has a shield-shaped spinisternite situated much as is that sclerite in *Danaus* (also see Fig. 87 of *Papilio*, Crampton, 1926). In the pierids examined, however, the spinisternite is long, slender, and more sharply forked; moreover, a triangular presternum directly behind the spinisternite appears in the Pieridæ apparently as an enlargement of a very small plate in that position in Papilio. The pierid meron extends half again as far dorsad as the anterior portion of the coxa.

NOTES ON THE THORACIC MUSCULATURE.

A few dissections of the thorax have been made for the purpose of homologizing some of the characters more accurately.

Musculature of the anepisternum.

The basalar muscles of the coxa and preepisternum are attached to a small thickened arm, the ba alare, at the dorsal margin of the anepisternum. In the Lepidoptera, then, the basalare comprises only a small muscle attachment slightly if at all separated from the anepisternum. The latter sclerite, aside from the muscles attached to the thickened arm at its dorsal margin, bears none of the basalar muscles from the coxa and sternum. Therefore there can be little doubt that it is not an enlarged basalare but is best termed the anepisternum.

In order to determine the fate of the anepisternum in the Papilionoidea, dissections of various species were made, and compared with the neuropteron *Corydalis* and moths of the specialized family Noctuidæ. In *Corydalis* the flexor muscle of the third axillary plate of the wing base is attached in two parts, one to the pleural apodeme,

the other larger one to the anepisternum. Weber (1928) shows this muscle in *Sialis*, where the same condition prevails. The noctuid moths (species undetermined) that were examined have this muscle attached as in these Neuroptera. For comparison may be mentioned a figure of the grasshopper *Dissosteira* (Snodgrass, 1927, Fig. 30) where this muscle is apparently broadly joined only to the posterior side of the pleural apodeme.

A different condition appears when the butterflies are studied. The hesperiid *Epargyreus tityrus* has as distinct an anepisternum as *Corydalis* and the noctuid moths. The attachment of the muscle of the third axillary, however, is not on the anepisternum in *Epargyreus* but upon the middle of the sternopleurite below the anepisternal suture. The smaller muscle which usually lies under this muscle is present and attached as usual to the posterior face of the pleural apodeme. In *Danaus archippus* and *Eurymus philodice* the muscular attachment is on the sternopleurite; in the former it is next the preepisternal suture while in *Eurymus* attachment occurs very close to the pleural apodeme.

In view of the fact that the muscle which is usually attached to the anepisternum in moths and Neuroptera is attached to the plate ventral to it in *Epargyreus* where the anepisternum has not disappeared, it is reasonable to conclude that in the Papilionoidea (Figs 45 to 50 except 48) the anepisternum has not necessarily fused with the sternopleurite. The length of the preepisternum leads to the same conclusion.

Musculature of the basalar pad.

In *Epargyreus* the metathoracic basalar pad bears a muscle attachment on its interior to which is fixed a large wing muscle from the eucoxa This fact fixes the nature of this sclerite as a basalare.

Musculature of the preepimeron.

In the Noctuidæ where the preepimeron is well developed is a short flat muscle which lies within the preepimeron and from the ventral end of which extends a long tendon to the furca. This muscle with its attachment is shown in Berlese (1909, Fig. 463). In Weber (1928) it is shown as a narrow muscle (Zwischenmuskel) in *Sialis* arising from the posterior face of the pleural apodeme and attached to the furca anteriorly.

GENERALIZATIONS.

These conclusions concerning the relationship of lepidopterous families, it must be remembered, are based entirely upon the characters described in the preceding notes. It can not be expected that any one character will parallel every other one in a series of different species arranged according to their supposed phylogeny. It is therefore remarkable to what an extent the various characters follow along the same phylogenetic path, to present nearly the same arrangement of families when different characters are used as the basis of arrangement.

When we attempt to derive from the comparison of various related species the antecedents of each of those species, we are continually faced by the varying results of the divergence of species from their extinct common stocks and so must exercise care in assigning definite relationships in many cases.

Those relationships which may be stated from the preceding notes may be summarized as follows:

1. The jugate families show marked relationship to the Trichoptera, and distinct separation from the frenate types.

2. The Eriocraniidæ and Micropterygidæ appear to arise close together while the Hepialidæ show some entirely different characters.

3. The "micro" families as a whole give evidence of the development of characters which are incorporated in various combinations into the structure of the more specialized "higher families." These characters are much more stable and uniform in the latter.

4. There seem to be two general lines of development of the specialized Lepidoptera, viz., that which culminates in the Noctuoidea and that which has produced the Papilionoidea. The morphology of the thorax would indicate that the noctuid line arises in the manner shown in the phylogenetic scheme of W. T. M. Forbes (1923). The evidence here (especially that of the preepisternal suture and the preepimeron) would indicate, however, that the Sphingidæ should be very close to the Noctuoidea, with the Geometroidea and Drepanoidea close together on one lower branch, and the Saturnioidea and Bombycoidea together on another branch arising between the Geometroidea and the Noctuoidea.

5. The thoracic characters of the noctuoid families indicate rather clearly that the Arctiidæ should be placed very close to the Noctuidæ and probably are higher on the same general line. The Noctuidæ are very close to and probably derived from the Notodontidæ. The Nolidæ and Euchromiidæ are close together; the former has been derived from the Arctiidæ, but the characters under examination in this study would indicate that it is not related and is even more primitive than some of the previously mentioned families. The lack of a preepimeron in the Nolidæ and Euchromiidæ as in the Liparidæ may indicate that these three families are close together but this evidence is too slight to form the basis of a definite assumption. The Liparidæ probably arise close to the Notodontidæ.

6. The derivation of the papilionoid line of descent presents considerable difficulty. A. D. Imms (1924, p. 438) says:

"The Papilionina are a tolerably natural group, but there is no general consensus of opinion as to their phylogeny. Both Hampson and Meyrick regard them as being derived from the Pyraline family Thyrididæ while other authorities derive them from the Castniidæ."

By referring to the figure of *Thyris* (Fig. 20) it will be observed that this species has no anepisternal suture but that there is no evidence that the anepisternum has disappeared as in the Papilionoidea but has merely been joined to the region ventral to it through disappearance of the suture. There is a similarity in the appearance of the preepisternum of *Thyris* to that of the Papilionoidea, but little can be judged from this character because of its variability.

There is one point in favor of the descent of the Papilionoidea from the cossids, supposed to be the antecedents of the castniids. *Carpocapsa* and *Archips* of the Tortricoidea, which includes the Cossidæ, have the precoxal suture arising close to the pleural suture and crossing the pleuron diagonally to the anterior margin of the basisternite as in such butterflies as *Danaus* and *Cercyonis*. It is to be expected that by the reduction of the anepisternum and the infolding of part of it in the groove of the pleural suture, the precoxal suture which arises from the anepisternal would appear some distance down the pleural suture. This infolding of a part of the episternum within the pleural groove is seen to some extent in the Geometridæ where the precoxal suture disappears for a short distance. *Lithocolletis* of the Tineoidea shows the same characteristic as mentioned above for the Tortricoidea. Both the Tortricoidea and the lower families of the noctuoid line are supposed to arise from the Tineoidea.

7. The arrangement of the papilionoid families according to thoracic characters seems to be quite clear. The Lycaenidæ probably give rise to two lines, in one of which the precoxal suture is preserved (Nymphalidæ), and in the other is lost (Papilionidæ and Pieridæ).

W. T. M. Forbes (1923) says that in the butterflies, "the line of descent through Hesperiidæ and Papilionidæ to the Pieridæ is clear, and the Nymphalidæ are certainly a direct offshoot of the Pieridæ; but the attachment of the Lycaenidæ

is less certain." This quotation is given to illustrate the diversity of opinion concerning gross relationships which still exists, and probably will exist for many years to come.

LITERATURE CITED

Berlese, A. 1909. Gli Insetti, Vol. 1. Milan.

Crampton, G. C. 1909. Contribution to the Knowledge of the Thoracic Sclerites of Insects. Proc. Acad. Nat. Sciences, Phila., p. 3.

1914a. Notes on the Thoracic Sclerites of Winged Insects. Ent. News 25: 15-25.

1914b. On the Misuse of the Terms Parapteron, Hypopteron, Tegula, Squamula, Patagium and Scapula. Journ. N. Y. Ent. Soc. 22: 248-261.

1920. A Comparison of the External Anatomy of the Lower Lepidoptera and Trichoptera from the Standpoint of Phylogeny. Psyche 27: 23-34.

1926. A Comparison of the Neck and Prothoracic Sclerites throughout the Orders of Insects from the Standpoint of Phylogeny. Trans. Am. Ent. Soc. 52: 199-248.

Forbes, W. T. M. 1923. Lepidoptera of New York and Neighboring States. Cornell Mem. 68.

1926. Lepidoptera, in Leonard: A List of the Insects of New York. Cornell Mem. 101, p. 532-687.

Imms, A. D. 1924. A General Text-book of Entomology. London.

Snodgrass, R. E. 1909. The Thorax of Insects and the Articulation of the Wings. Proc. U. S. Nat. Mus. 26: 511-595.

1927. Morphology and Mechanism of the Insect Thorax. Smithson. Misc. Coll. 80 (No. 1); pp. 108.

Tillyard, R. J. 1919. Panorpoid Complex. Proc. Linn. Soc. N. So. Wales 44: 533-718.

Weber, Hermann. 1924. Das Thorakalskelett der Lepidopteren. Zeitschr. f. Anat. u. Entwickl. 73: 277-331.

1928. Die Gliederung der Sternopleuralregion des Lepidopterenthorax. Zeitschr. f. wissensch. Zool. 131: 181-254.

Young, B. P. 1921. Attachment of the Abdomen to the Thorax in Diptera. Cornell Mem. 44.

ABBREVIATIONS.

The subscripts 2, 3, indicate that the structures in question belong to the mesothorax and metathorax, respectively.

a.......Anepisternal suture.
aes.....Anepisternum.
ba......Basalar pad.
bc......Basicostal suture.
bs......Basisternite.
c.......Pleural suture.
ec......Eucoxa.
em......Epimeron.
es......Episternum.
fs......Furcisternite.
g.......Marginopleural suture.
h.......Midventral suture.
m......Meron.
p.......Patagium.
pba.....Posterior basalare.
pem....Preepimeron.
pes.....Preepisternum.
s......Sternum.
sa.....Subalare.
sl.......Sternal lobe.
spl.....Sternopleurite.
ss.....Spinisternite.
t......Tegula.
tga.....Tegular arm.
v.......Metepisternal suture.
w.......Preepisternal suture.
wp.....Pleural wing process.
x......Epicoxal suture.
y......Precoxal suture.
z.......Anepisternal sutural connective.

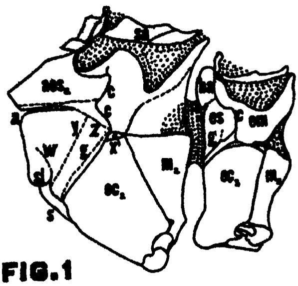


FIG. 1

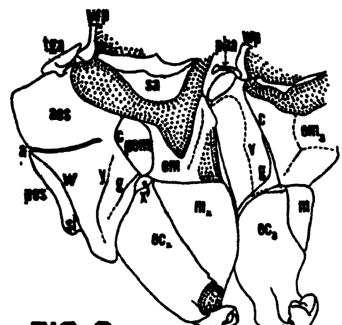


FIG. 2

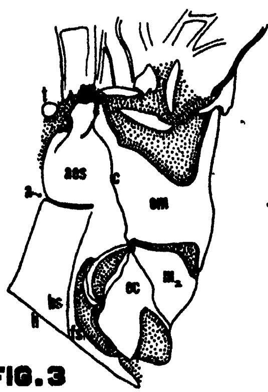


FIG. 3

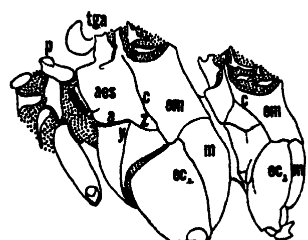


FIG. 4

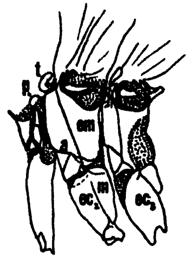


FIG. 5

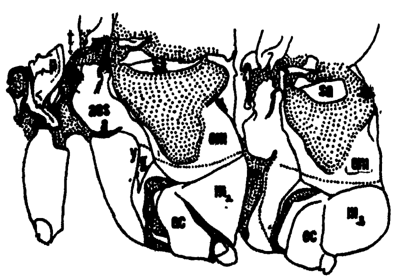


FIG. 6

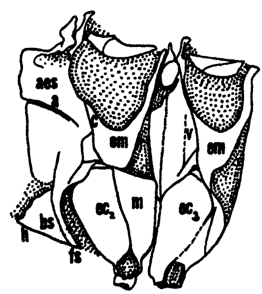


FIG. 7

Fig. 1. *Melittia satyriniformis*, mesopleuron and metapleuron.
Fig. 2. *Catocala concumbens*, mesopleuron and metapleuron.
Fig. 3. *Corydalis cornuta*, mesopleuron and sternum.
Fig. 4. *Neuronia* sp., propleuron, mesopleuron and metapleuron.
Fig. 5. *Micropteryx aruncella*, propleuron, mesopleuron and metapleuron.
Fig. 6. *Phassus huebneri*, propleuron, mesopleuron and metapleuron.
Fig. 7. *Tegeticula yuccasella*, mesopleuron, mesosternum, and metapleuron.

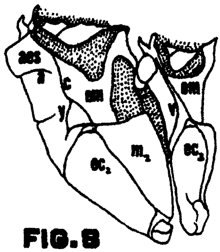


FIG. 8

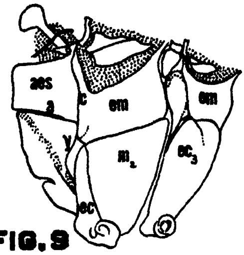


FIG. 9

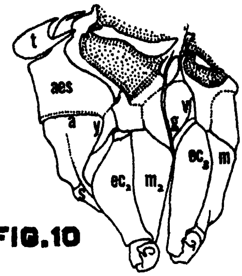


FIG. 10

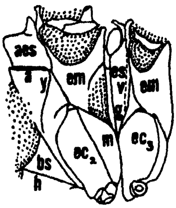


FIG. 11

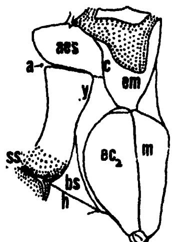


FIG. 12

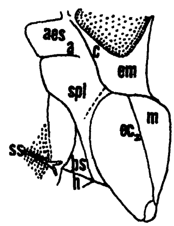


FIG. 13

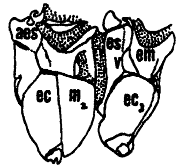


FIG. 14

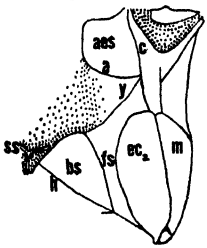


FIG. 15

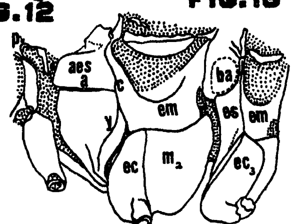


FIG. 16

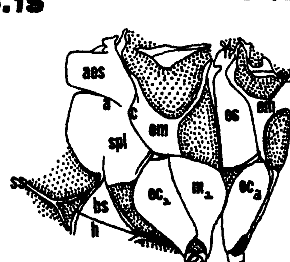


FIG. 17

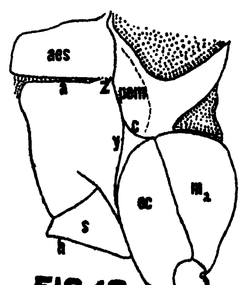


FIG. 18

Fig. 8. *Adela purpura*, mesopleuron and metapleuron.
Fig. 9. *Megalopyge crispata*, mesopleuron and metapleuron.
Fig. 10. *Cnidocampa flavescens*, mesopleuron and metapleuron.
Fig. 11. *Archips* sp., mesopleuron and sternum, and metapleuron.
Fig. 12. *Apheloseita* sp., mesopleuron and sternum.
Fig. 13. *Tineola bisselliella*, mesopleuron and sternum.
Fig. 14. *Simaethis pariana*, mesopleuron and metapleuron.
Fig. 15. *Lithocolletis* sp., mesopleuron and sternum.
Fig. 16. *Thyridopteryx ephemeraeformis*, propleuron, mesopleuron and metapleuron.
Fig. 17. *Atteva punctella*, mesopleuron and sternum, and metapleuron.
Fig. 18. *Harrisina americana*, mesopleuron and sternum.

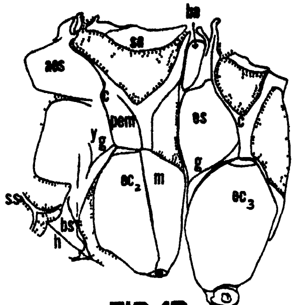


FIG. 19

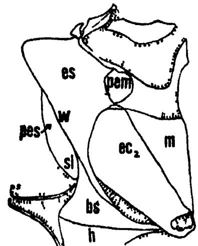


FIG. 20

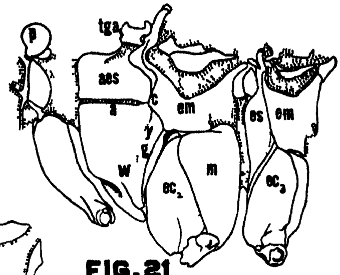


FIG. 21

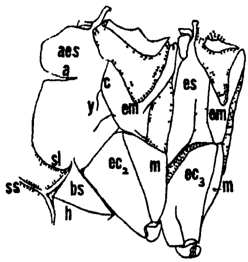


FIG. 22

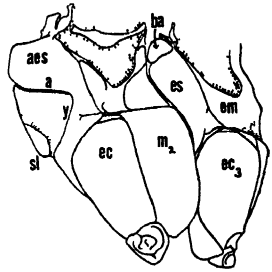


FIG. 23

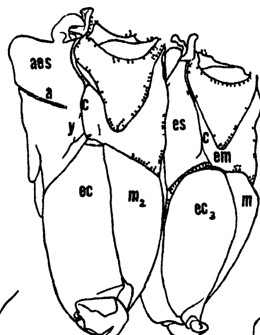


FIG. 24

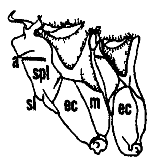


FIG. 25

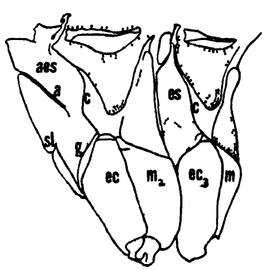


FIG. 26

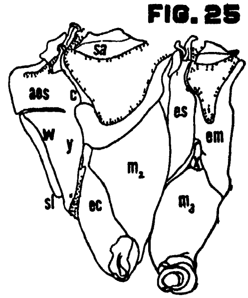


FIG. 27

Fig 19 *Phthorimaea operculella*, mesopleuron and sternum, and metapleuron
Fig 20 *Thyris maculata*, mesopleuron and sternum
Fig 21 *Prionoxystus robiniæ*, propleuron, mesopleuron and metapleuron
Fig 22 *Desmia funeralis*, mesopleuron and sternum, and metapleuron
Fig 23 *Carpocapsa pomonella*, mesopleuron and metapleuron
Fig 24 *Galleria mellonella*, mesopleuron and metapleuron
Fig. 25 *Crambus* sp , mesopleuron and metapleuron
Fig 26 *Ephestia kuehniella*, mesopleuron and metapleuron
Fig 27 *Bombyx mori*, mesopleuron and metapleuron

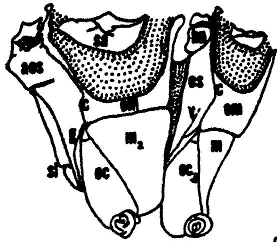


FIG. 28

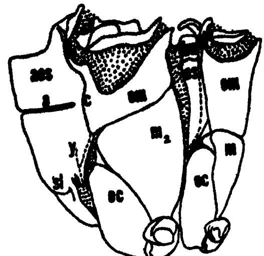


FIG. 29

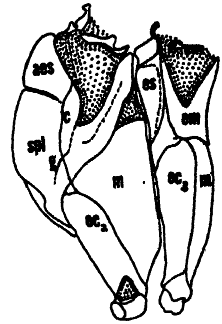


FIG. 30

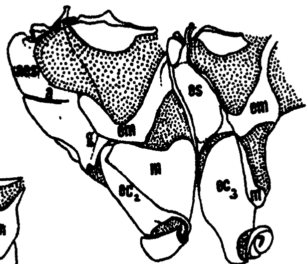


FIG. 31

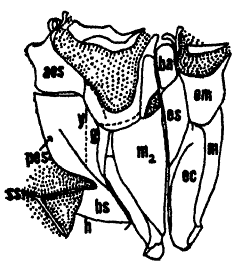


FIG. 32

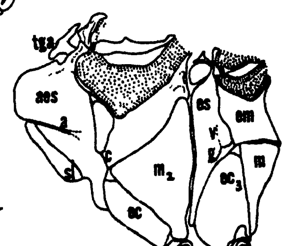


FIG. 33

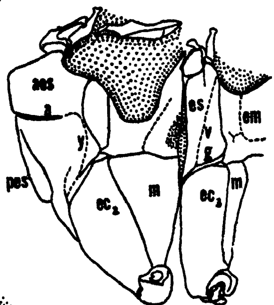


FIG. 34

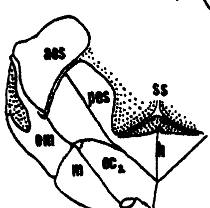


FIG. 35

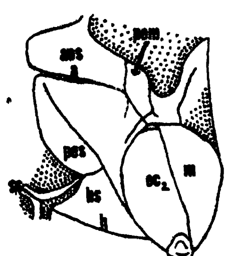


FIG. 36

Fig. 28. *Automeris io* (male), mesopleuron and metapleuron.
Fig. 29. *Malacosoma americana*, mesopleuron and metapleuron.
Fig. 30. *Erannis tiliaria* (male), mesopleuron and metapleuron.
Fig. 31. *Brephos infans*, mesopleuron and metapleuron.
Fig. 32. *Oreta irrorata*, mesopleuron and sternum, and metapleuron.
Fig. 33. *Sphinx gordius*, mesopleuron and metapleuron.
Fig. 34. *Septis arctica*, mesopleuron and metapleuron.
Fig. 35. *Apatelodes torrefacta*, mesosternum with pleuron from below.
Fig. 36. *Lygranthoecia marginata*, mesopleuron and sternum.

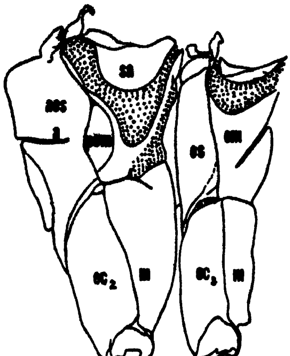


FIG.37

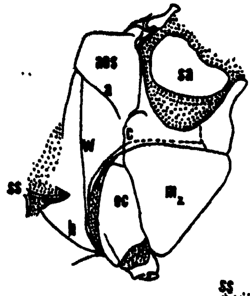


FIG.38

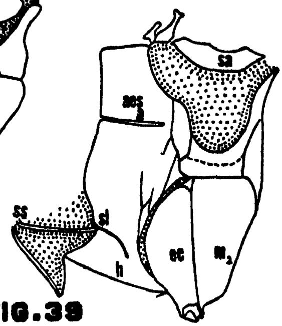


FIG.39

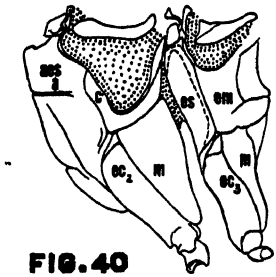


FIG.40

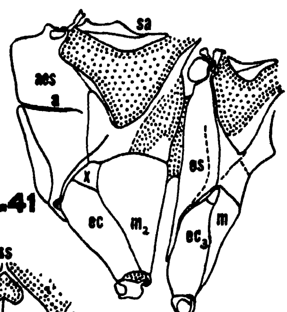
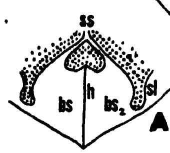


FIG.41



A

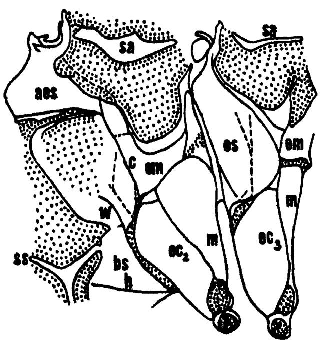


FIG.42

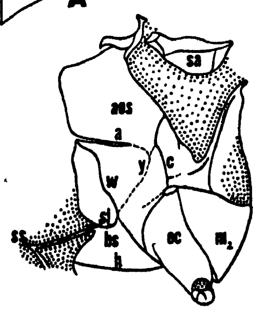


FIG.43

Fig. 37. *Datana ministra*, mesopleuron and metapleuron.
Fig. 38. *Anisota senatoria*, mesopleuron and sternum.
Fig. 39. *Melalopha inclusa*, mesopleuron and sternum.
Fig. 40. *Hemerocampa leucostigma*, mesopleuron and metapleuron.
Fig. 41. *Estigmene acraea*, mesopleuron and metapleuron.
Fig. 41a. Same species, mesosternum.
Fig. 42. *Scepsis fulvicollis*, mesopleuron and sternum, and metapleuron.
Fig. 43. *Autographa falcigera*, mesopleuron and sternum.

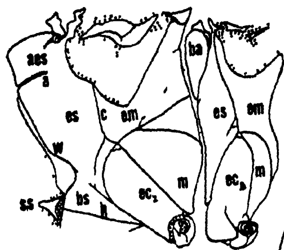


FIG. 44

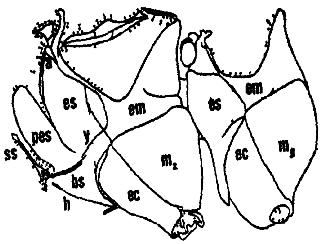


FIG. 45

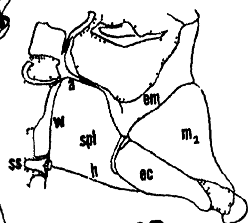


FIG. 46

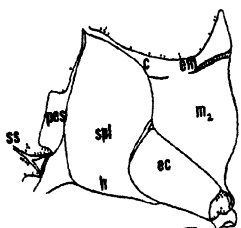


FIG. 47

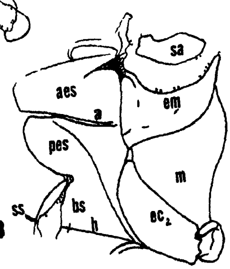


FIG. 48

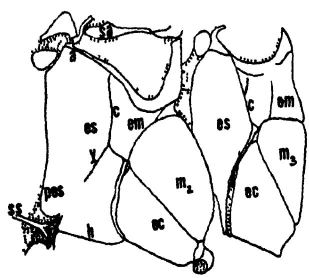


FIG. 49

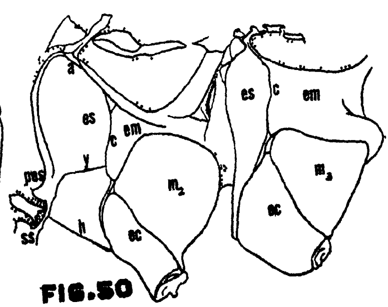


FIG. 50

Fig 44 *Epargyreus tityrus*, mesopleuron and sternum and metapleuron
Fig 45 *Heodes hypophlaeas*, mesopleuron and sternum, and metapleuron.
Fig 46 *Papilio turnus* mesopleuron and sternum
Fig 47 *Eurymus philodice* mesopleuron and sternum
Fig 48 *Amphion nessus*, mesopleuron and sternum
Fig 49 *Cercyonis alope*, mesopleuron and sternum and metapleuron
Fig 50 *Danaus archippus*, mesopleuron and sternum, and metapleuron.

THE BIONOMICS OF SOME TABANIDÆ (DIPTERA).*

ALAN STONE,
Dartmouth College, Hanover, N. H.*

Although the early stages of the Tabanidæ have been studied in considerable detail, both in this country and in other parts of the world, only a relatively few species of this large family were involved in these studies. The importance of horseflies as irritating pests of man and domestic animals, and as potential vectors of disease organisms makes a further study of their biology desirable. The following study was carried out at Ithaca, N. Y., only a few larvæ being collected elsewhere.

BIONOMICS IN GENERAL.

THE ADULTS.

Tabanidæ are generally robust flies with a stout body, large head, powerful wings and a heavy, depressed abdomen. They range in size from the smaller *Chrysops* species, no larger than a house-fly, to the large *Tabanus* species, with a wing spread of over 2½ inches

In the majority of the species, the females are blood-sucking. They have a wide range of hosts, the larger mammals being most frequently attacked. Certain species of the genus *Tabanus* and most *Chrysops* species readily attack man. A medium-sized *Tabanus* will take from 8 to 10 minutes to complete a blood meal and will remove 0.2 cc. of blood during that time. The males exclusively, and the females to a considerable extent, feed on plant juices, excreta from certain insects, and other liquids containing nutritive material. The writer collected a female of *Tabanus orion*, one of our largest species, on Queen Anne's Lace (*Daucus carota* L.), and all of the specimens of *Buplex rasa*, five in number, on the same plant. It is doubtful if the North American *Buplex* species, or *Goniops chrysocoma*, are blood-sucking.

*This paper is a portion of a thesis presented to the faculty of the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy, September, 1929.

The adults are lovers of sunlight, warmth and moisture. They possess a strong positive phototropism. They are attracted to moving objects, such as automobiles and trains, and will also collect around, and in, a standing automobile.

TABLE I.

SEASONAL DISTRIBUTION OF THE TABANIDAE AT ITHACA, N. Y.

	May	June	July	August	Sept.
Chrysops carbonarius..........	. . x x	x x x x	. . . .	. . . .	. . . .
Tabanus lasiophthalmus.........	. . x x	x x x x	x x . .	. . . .	. . . .
Chrysops cuclux...............	. . . x	x x . .	. . . .	. . . .	. . . .
" *celer*................	. . . x	x x x x	. . . .	. . . .	. . . .
" *niger*................	. . . x	x x x x	x x . .	. . . .	. . . .
" *callidus*..............	. . . .	. x x x	x x x x	x . . .	. . . .
" *excitans*.............	. . . .	. . x x	. . . .	. . . .	. . . .
" *indus*................	. . . .	. . x x	x x . .	. . . .	. . . .
Tabanus carolinensis.......	. . . .	. . x x	x x . .	. . . .	. . . .
" *lineola*	. . . .	. . x x	x x x x	x x . .	. . . .
" *trispilus*.............	. . . .	. . x x	x x x x	x x x x	. . . .
" *vivax*................	. . . .	. . x x	x x x x	x x x x	. . . .
" *nivosus*	. . . .	. . . x	x . . .	. . . .	. . . .
" *pumilus*	. . . .	. . . x	x . . .	. . . .	. . . .
" *trepidus*	. . . .	. . . x	x x . .	. . . .	. . . .
" *reinwardtii*...........	. . . .	. . . x	x x x x	x . . .	. . . .
Chrysops geminatus...........	. . . .	. . . x	x x x x	x x . .	. . . .
" *wiedemanni*..........	. . . .	. . . x	x x x x	x x . .	. . . .
Tabanus bicolor..............	. . . .	. . . x	x x x x	x x . .	. . . .
" *stygius*..............	. . . .	. . . x	x x x x	x x . .	. . . .
" *atratus*..............	. . . .	. . . x	x x x x	x x x .	. . . .
Chrysops vittatus.............	. . . .	. . . x	x x x x	x x x x	. . . .
Tabanus epistates......	. . . .	. . . .	x x x .	. . . .	. . . .
" *ohioensis*............	. . . .	. . . .	x x x .	. . . .	. . . .
Chrysops univittatus.....	. . . .	. . . .	x x x .	. . . .	. . . .
" *moechus*..	. . . .	. . . .	x x x x	. . . .	. . . .
Tabanus affinis...............	. . . .	. . . .	x x x x	. . . .	. . . .
Chrysops montanus............	. . . .	. . . .	x x x x	x . . .	. . . .
Tabanus microcephalus..... ...	. . . .	. . . .	x x x x	x x x x	. . . .
" *costalis*.............	. . . .	. . . .	. x x x	x x x x	x x . .
" *longus*..............	. . . .	. . . .	. . x .	. . . .	. . . .
Chrysops striatus.............	. . . .	. . . .	. . x x	. . . .	. . . .
Tabanus giganteus............	. . . .	. . . .	. . . x	. . . .	. . . .
" *superjumentarius*.....	. . . .	. . .	. . . .	x . . .	. . . .
Goniops chrysocoma...........	. . . .	. . . .	. . . .	. x x .	. . . .
Buplex rasa..................	. . . .	. . . .	. . . .	. x x x	. . . .
Tabanus orion................	. . . .	. . . .	. . . .	. . x x	. . . .

The writer collected a number of *Tabanus* species inside of a sedan. They are attracted to water, and both sexes are often seen, either crawling down to the water's edge to drink, or dipping the tip of the abdomen into it as they fly rapidly over

the surface. The reason for the latter habit has not been explained but is of common occurrence.

Since Tabanidæ are lovers of hot weather, the flying season of the adults is relatively short. In the vicinity of Ithaca, the earlier species, such as *Chrysops carbonarius* and *Tabanus lasiophthalmus*, appear sometime in the second week of May. During the first two weeks of July, one finds horseflies in the greatest abundance, both as to species and individuals. At this time, our most abundant species, *Chrysops callidus, geminatus*, and *vittatus* and *Tabanus lasiophthalmus, costalis* and *lineola* are on the wing. By early September, most of the species have disappeared, although one may find a straggling few late into September.

Table I shows the approximate seasonal distribution of those species found at Ithaca, arranged according to the time of their first appearance. Each month is divided into four parts and the collection of a species within any fourth indicated by an x. For the rarer species, this table is of little significance.

Mating is not frequently observed. It almost always occurs in the morning, from before sunrise to about nine o'clock. When the mating pair is at rest, the male hangs inert, and when in the air, the male does the flying.

Since a large number of Tabanidæ are semi-aquatic as larvæ, it is to be expected that their eggs would be found in the vicinity of the water. This is true for most of those observed. The places of oviposition may be briefly classified as follows:

1. Foliage or other objects over shallow, quiet water; the edges of shallow pools, etc.
2. Foliage or other objects over relatively deep water, as on water plants a considerable distance from shore, and on ledges over deep water.
3. Stones projecting above the bed of a flowing stream.
4. Vegetation over either moist or quite dry soil.

The method of oviposition is quite similar in all species observed, the only differences being due to a difference in the number of layers in the completed mass and in the substratum on which the eggs are placed. The process has been described so carefully by Hine (1906) and Cameron (1926) that it is unnecessary to repeat it here.

THE EGG.

The eggs are laid in masses, varying in number from 100 to 800. All of the eggs may not be laid at one time. The mass may be composed of a single layer, as in most of the *Chrysops* species, or of several layers, as in most of the *Tabanus* species. When in a single layer, they partially overlap each other. When in several layers, they stand at an angle of 45° or more to the surface. As the eggs are laid, they are covered with a gluey secretion which acts as a waterproof covering and binds the eggs together. Some species cover the egg mass with a thick, protective secretion.

The individual egg is cylindrical, narrower at the ends and either straight or slightly curved. It varies in length from 1 to 2.7 mm. and in diameter from 2 to .4 mm.

The duration of the egg stage, in bright sunlight, is from 5 to 7 days, in most species. This may be prolonged considerably if the weather is cool and cloudy, the embryo being fully developed but not hatching until favorable conditions are present or unless mechanically stimulated. All of the eggs usually hatch about the same time, the larvæ coming out in a mass and sticking together, most of them dropping to the ground or water together.

THE LARVA.

EXTERNAL ANATOMY.

Tabanid larvæ are characterized by possessing eleven body segments exclusive of the head and siphon, a slender cylindrical body tapering at both ends, a small retractile head with prominent downward pointing mandibles,' a shiny, striated integument, and a single posterior siphon. These characters, in association with the usually visible Graber's organ within the 10th and 11th segments, will serve to distinguish all tabanid larvæ so far described, with the exception of *Goniops chrysocoma*. This anomalous species has a club-shaped body swollen posteriorly, the striæ are overshadowed by the mammillated portions of the integument, no distinct siphon is visible, and the opaqueness of the integument in older specimens completely conceals Graber's organ. In the following, more detailed description, *Goniops* is not included, but only the typical tabanid larvæ.

Head.—The head is small and may be wholly retracted or extended nearly half the total length of the head and pharyngeal capsule combined.* The mandibles are large, strong, parallel to each other, curved ventrally, often serrated along the inner margin and usually dark brown or black in color. The labrum forms a hook-like projecting septum between them. The maxillæ are well developed and wholly or largely membranous with well developed palpi. The antennæ are distinct, three jointed. Between each antenna and the dorsal median line, is a bunch of stiff, recurved bristles. These are often reddish or brownish in color. A short distance posterior to the head capsule, on each side, lies a dark ocellus.

Integument.—The non-pubescent integument is, for the most part, characterized by the presence of minute, longitudinal striæ. In certain places, they are partially or completely lacking, as in the dorsum of the thorax in the genus *Tabanus*. In other places, they are very fine and closely packed together as on the siphon. Often they are numerous on the anterior portion of an abdominal segment and fewer and wider apart posteriorly. Usually they are closer together on the lateral areas than on the dorsum or venter. The integument is ordinarily quite transparent and one can see the internal organs quite readily.

In addition to the shiny integument, there are present more or less extensive areas of fine, felt-like pubescence. This pubescence arises from the outer layer of the integument and is arranged in a fairly definite pattern, according to the species. It is usually brownish in color and probably derives much of its color from dirt particles adhering to it. In certain places, as on the anal segment of *Chrysops moechus*, the pubescent character of the covering cannot be discerned without a compound microscope. In others, especially on the anal protuberances, it is very evident.

Tabanid larvæ may be white, yellowish white, yellowish brown, olive green or distinctly green. *Tabanus trepidus*, living in sphagnum moss, is bright green. *Chrysops carbonarius* is yellowish brown to olive green. Many others, among them *Chrysops vittatus* and *C. celer*, are distinctly white or creamy-white.

Thorax.—Each of the three thoracic segments is divided into a dorsal, a ventral and two lateral areas separated from each other by the dorso-lateral and ventro-lateral lines. The prothorax is grooved along the mid-ventral line. Usually, there is an anterior ring of pubescence on each segment. Ventrally, each segment bears a more or less distinct pair of bristles. The prothorax is narrow anteriorly with the head telescoping into it. Between the prothorax and the mesothorax, in a lateral, vertical slit, there is a very small thoracic spiracle on each side.

Abdomen.—The first seven abdominal segments are quite similar in structure. The eighth is modified to bear the siphon and anus The prolegs, on the anterior portion of each abdominal segment except

*For a very detailed description of a tabanid larva, and particularly the head, one should consult Webb and Wells (1924), pp. 14–17.

the last, consist of a dorsal transverse pair usually fused and often scarcely visible, a more or less prominent lateral pair, and two rounded ventral pairs. These prolegs are usually larger on the posterior segments. In certain species, they are very rudimentary. They often bear rows of recurved bristles at the tip. The pubescent annuli, when present, are for the most part confined to the anterior margin of abdominal segments 1-7. Posterior annuli may be present, particularly on the posterior segments. Each abdominal segment telescopes into the preceding one to some extent.

The anal segment is broad at the base and usually narrows considerably beyond the anus into a sub-conical, upward projecting portion bearing the siphon. Ventrally, the anus, a longitudinal slit, is surrounded by an anterior and a posterior anal lobe. Commonly, there is a posterior ring of pubescence around the anal segment and anterior to this either dorso-lateral projections or spots. Laterally, the anal pubescence is often joined to the posterior ring, or the whole ventral area from the anus posteriorly is pubescent.

The siphon extends from the anal segment as a rounded or elongate projection, telescoping into the anal segment. At its tip, the two tracheal trunks come in contact, the spiracle consisting of a vertical slit or a freely exsertile, sharp, compressed spine. (Figures 3 and 4.)

INTERNAL ANATOMY.

A detailed discussion of the internal anatomy is not within the scope of this work, dealing as it does, primarily, with the identification of the immature stages of Tabanidæ and with their biology. A number of the internal structures may be observed, however, in living, transparent larvæ.

The two main tracheal trunks run nearly the entire length of the body. They may be slender and quite sinuous, making a loop in the 6th and 7th abdominal segments or they may be swollen into heavy tubes serving as air chambers and narrow only near the posterior end. As far as is known, tabanid larvæ are metapneustic, the anterior spiracles not being functional. The pharynx is enclosed within the pharyngeal pouch and moves with the head. The mid-gut usually contains a colored fluid, the color depending upon the food last ingested. The Malpighian tubules ordinarily show as coiled yellowish or brownish tubes in the posterior part of the body. The very transparent, dorsal blood vessel can be seen in larger larvæ, the contractions proceeding from the back forward.

Of particular interest is Graber's organ, that peculiar pear-shaped sac, broader anteriorly with a slender tube opening near the base of the siphon dorsally. Within the sac are a number of capsules containing black, pediceled bodies. The whole structure is richly provided with nerves and muscles and in life keeps up a nearly continual, lateral oscillation. This organ has been described and its possible functions discussed so fully by more competent writers that further remarks are

superfluous. For a complete rèsumè of the literature on it, up to 1920, one should consult Marchand (1920) pp. 29–43. Cameron (1926) also writes quite fully upon it. For other features of the internal anatomy, Patton and Cragg (1913) and Stammer (1924) are particularly valuable.

GROWTH.

Almost immediately after emerging from the egg, the first ecdysis takes place. According to Webb and Wells (1924), the second instar larvæ are ready to cast the skin of the first instar before hatching, and as soon as they hatch, often before they reach the water, this is done. The writer failed to determine the number of molts in *Tabanus atratus* larvæ. Mitzmain (1913) working in the Philippines, found *Tabanus striatus* having only three instars, but he makes no mention of the first brief one. Isaac (1924) working with improved technique in India, found *T. striatus*, *rubidus*, and *tenens* molting seven times and that *T. crassus* molted eight times. It is quite likely that most tabanid larvæ molt oftener than was at first supposed.

A characteristic of tabanid larvæ, noted by many who have worked with them, is the variation in their rate of growth. Thus Mitzmain (1913) found 12 day old larvæ of *Tabanus striatus*, reared under exactly the same conditions, varying in length from 3 to 11 mm. Hine (1906) found 25 day old *T. lasiophthalmus* larvæ varied from 3 to 7 mm. Ten day old larvæ of *T. atratus*, reared by the writer, varied from 3 to 6 mm. The older the larvæ grow, the greater the variation becomes. This probably helps to explain the extreme variation in the size of larvæ of a given species collected in the field. Another factor entering there is the difference in the time of egg laying. This may extend over a period of two months.

DURATION OF THE LARVAL STAGE.

In the temperate portions of North America, it is probable that the majority of species and the majority of individuals of a species require only nine or ten months to complete their larval life. However, since the rate of growth is so variable and the oviposition period so extended, there is probably quite a bit of holding over to a second season. This occurs frequently in the laboratory. The writer never succeeded in rearing to the adult stage any larva doing this, but did get a prepupa of *Chrysops carbonarius* from a larva collected over 18 months

previously. Furthermore, when the larva was collected, on July 29th, it was apparently fully grown. A number of other larvæ of this species and one of *Chrysops vittatus* were kept alive fully as long. Cameron (1926) and others, have observed this same phenomenon in their rearing work. If they fail to pupate at the time they should, they will ordinarily pass over to another year. This probably takes place in nature also. The writer collected larvæ of *Chrysops carbonarius* on October 4th, ranging in length from 3 to 15 mm. If they all emerged from the egg the same season, which is probable, one wonders whether they would all be ready to pupate the following May.

Hine, (1906), judging from the rate of growth of the larva of *Tabanus stygius*, felt that it must take two seasons to reach maturity. An adult male of *Tabanus atratus*, reared by the writer, emerged on July 10th from a larva which left the egg on July 18th of the previous year. This, of course, was under laboratory conditions.

LARVAL ACTIVITIES.

Newly hatched larvæ drop to the ground or water and soon disappear from sight, burrowing into the soil or sinking to the bottom of the pond or stream and burrowing into the mud. Certain species have strongly developed tracheal trunks enabling them to float, but as soon as they reach the margin, they hide themselves in the mud or debris.

As is characteristic with larvæ, their chief aim in life is to feed. This they do from the time they leave the egg until winter comes. Then the half grown larvæ hibernate out of the reach of frost, many of them, probably, burrowing into the mud below ponds. They cannot surviye in frozen soil, at least if it is moist, as the writer discovered when trying to imitate natural conditions. Active larvæ were collected at the margins of ponds as early as March 19th and as late as December 1st. In the spring, after a more or less brief period of feeding, depending on the species, pupation takes place.

All of this time they are hidden from sight. Occasionally one will find a *Tabanus* larva, especially in the spring, floating on the surface of the water. It is out of its natural environment and will burrow into the soil as soon as it can. One has to dig in the mud, sift out the rubbish and debris of the shore line, dig in rotten logs or search the leaf mold of the forest floor to find them.

Food.—Tabanid larvæ are either carnivorous or saprophagous. Most of the *Tabanus* species are the former. Their prominent mandibles are fitted for piercing and tearing and they use them effectively on earthworms, snails, other insect larvæ and each other. The writer has watched, under the binocular microscope, the feeding of *Tabanus reinwardtii* and *Tabanus atratus* on earthworms. Contact is made by means of a sharp downward thrust of the mandibles. (If one touches the head of a large *Tabanus* larva with a pair of forceps, a distinct click can be heard as the mandibles strike the metal. This downward thrust may be felt as a sharp, stinging prick if it strikes the hand, not sufficient to break the skin, but smarting for several hours after it occurs.) Having secured a hold, by means of a twisting, chewing motion an opening is made in the side of the worm and the whole head thrust in. Then turning first one way and then the other, the fluid contents are sucked out and they can be seen flowing through the pharynx and making the mid-gut red.

Young larvæ of *Tabanus atratus* and other unknown species were fed on crustacea, bits of worm, chironomid larvæ and, best of all, mosquito larvæ. Only these young larvæ were kept in the same receptacle for any length of time and cannibalism was frequently observed. Although the larger larvæ were isolated most of the time, the writer saw no evidence of cannibalism among *Chrysops* species when they were together in close quarters. In fact, the actual attack of a *Chrysops* larva upon another animal was never observed. Fragments of earthworms were found in the jelly glasses, apparently eaten by *C. carbonarius* and *C. celer.* However, the mid-gut of all the *Chrysops* species was rarely red and usually green or black. Cameron (1926) is emphatic in declaring that *Chrysops* larvæ are entirely saprophagous, never feeding on living animal food and refusing it even when starving. It is doubtful if this can be applied to all *Chrysops* species, but certainly most of the food consists of organic matter in the soil, taken from it as it passes through the intestine. Cameron (1926) also found *Tabanus hirtulus* subsisting entirely on dead organic matter and felt that even the admittedly carnivorous species subsisted to some extent on it.

Locomotion.—Tabanid larvæ crawl over surfaces and through the soil by means of a peristaltic movement and telescoping of

previously. Furthermore, when the larva was collected, on July 29th, it was apparently fully grown. A number of other larvæ of this species and one of *Chrysops vittatus* were kept alive fully as long. Cameron (1926) and others, have observed this same phenomenon in their rearing work. If they fail to pupate at the time they should, they will ordinarily pass over to another year. This probably takes place in nature also. The writer collected larvæ of *Chrysops carbonarius* on October 4th, ranging in length from 3 to 15 mm. If they all emerged from the egg the same season, which is probable, one wonders whether they would all be ready to pupate the following May.

Hine, (1906), judging from the rate of growth of the larva of *Tabanus stygius*, felt that it must take two seasons to reach maturity. An adult male of *Tabanus atratus*, reared by the writer, emerged on July 10th from a larva which left the egg on July 18th of the previous year. This, of course, was under laboratory conditions.

LARVAL ACTIVITIES.

Newly hatched larvæ drop to the ground or water and soon disappear from sight, burrowing into the soil or sinking to the bottom of the pond or stream and burrowing into the mud. Certain species have strongly developed tracheal trunks enabling them to float, but as soon as they reach the margin, they hide themselves in the mud or debris.

As is characteristic with larvæ, their chief aim in life is to feed. This they do from the time they leave the egg until winter comes. Then the half grown larvæ hibernate out of the reach of frost, many of them, probably, burrowing into the mud below ponds. They cannot survive in frozen soil, at least if it is moist, as the writer discovered when trying to imitate natural conditions. Active larvæ were collected at the margins of ponds as early as March 19th and as late as December 1st. In the spring, after a more or less brief period of feeding, depending on the species, pupation takes place.

All of this time they are hidden from sight. Occasionally one will find a *Tabanus* larva, especially in the spring, floating on the surface of the water. It is out of its natural environment and will burrow into the soil as soon as it can. One has to dig in the mud, sift out the rubbish and debris of the shore line, dig in rotten logs or search the leaf mold of the forest floor to find them.

Food.—Tabanid larvæ are either carnivorous or saprophagous. Most of the *Tabanus* species are the former. Their prominent mandibles are fitted for piercing and tearing and they use them effectively on earthworms, snails, other insect larvæ and each other. The writer has watched, under the binocular microscope, the feeding of *Tabanus reinwardtii* and *Tabanus atratus* on earthworms. Contact is made by means of a sharp downward thrust of the mandibles. (If one touches the head of a large *Tabanus* larva with a pair of forceps, a distinct click can be heard as the mandibles strike the metal. This downward thrust may be felt as a sharp, stinging prick if it strikes the hand, not sufficient to break the skin, but smarting for several hours after it occurs.) Having secured a hold, by means of a twisting, chewing motion an opening is made in the side of the worm and the whole head thrust in. Then turning first one way and then the other, the fluid contents are sucked out and they can be seen flowing through the pharynx and making the mid-gut red.

Young larvæ of *Tabanus atratus* and other unknown species were fed on crustacea, bits of worm, chironomid larvæ and, best of all, mosquito larvæ. Only these young larvæ were kept in the same receptacle for any length of time and cannibalism was frequently observed. Although the larger larvæ were isolated most of the time, the writer saw no evidence of cannibalism among *Chrysops* species when they were together in close quarters. In fact, the actual attack of a *Chrysops* larva upon another animal was never observed. Fragments of earthworms were found in the jelly glasses, apparently eaten by *C. carbonarius* and *C. celer.* However, the mid-gut of all the *Chrysops* species was rarely red and usually green or black. Cameron (1926) is emphatic in declaring that *Chrysops* larvæ are entirely saprophagous, never feeding on living animal food and refusing it even when starving. It is doubtful if this can be applied to all *Chrysops* species, but certainly most of the food consists of organic matter in the soil, taken from it as it passes through the intestine. Cameron (1926) also found *Tabanus hirtulus* subsisting entirely on dead organic matter and felt that even the admittedly carnivorous species subsisted to some extent on it.

Locomotion.—Tabanid larvæ crawl over surfaces and through the soil by means of a peristaltic movement and telescoping of

the segments. At each contraction wave, the prolegs are invaginated. The prolegs with their rows of recurved bristles are of great value in aiding them to push through the soil. They can move backward nearly as readily as they can forward. Their ability to push through narrow places is very marked and if a large one is held in the hand, it will crawl between the base of the fingers quite easily.

The larger species, with enlarged tracheal trunks enabling them to float, progress slowly, on the surface of the water, by means of their peristaltic action, and rapidly by a strong lashing of the posterior part of the body. The tip of the anal segment is brought forward until it nearly touches the side of the larva and then suddenly straightened, propelling the larva forward its own length or more.

Tropisms.—Probably the strongest of the tropic reactions exhibited by tabanid larvæ is that of a negative phototropism. If placed upon a table in front of a window, they always crawl away from it. Since they are burrowing animals, fond of being entirely in contact with the soil, it may be said that they are postively thigmotropic. They may have a slight positive geotropism but the writer conducted no experiments to determine this accurately. It is quite certainly weaker than its negative phototropism.

THE PREPUPAL PERIOD AND PUPATION.

Twenty-four to forty-eight hours before the final ecdysis, the larva begins the prepupal period. This is characterized chiefly by the projection of the anterior spiracles laterally at the base of the prothorax. They appear as slender white tubes projecting laterally and anteriorly. At the same time, the head is somewhat invaginated and becomes immovably fixed and the thorax becomes slightly swollen. The prepupa is usually quite well developed 48 hours before pupation occurs.

Pupation takes place by the splitting of the integument of the thorax along the mid-dorsal line and the crawling out of the pupa by means of a twisting motion of the abdomen, aided by the bristles surrounding the abdominal segments and by the terminal aster. The mouth parts remain attached to the crumpled exuvium and during the casting of the skin, lie on the venter pointing posteriorly. For successful pupation, the prepupa must be in quite compact soil to hold the exuvium as the pupa comes out.

THE PUPA.

EXTERNAL ANATOMY.

The pupa of the Tabanidæ is obtected, the wings, legs and mouthparts being glued to the surface of the body. Anteriorly, it is rather abruptly rounded, while posteriorly, it tapers to a small terminal segment. When first formed it is pale yellowish or greenish; later, it becomes yellowish brown or ferruginous.

Head and Thorax.—These are closely fused. Anteriorly, to each side are the short, rapidly tapering antennæ overlying the eyes. Between these is usually a heavy ridge of chitin, the frontal carina, divided medianly by a notch and sometimes with each side again divided into two parts. Above these lie a pair of setiferous tubercles bearing one or two pairs of setæ. Ventrally, on the fronto-ventral plate, are two pairs of setæ and below these, a pair of short palpal sheaths. Back of the eyes, on the mesothorax, lie the prominent thoracic spiracles, flattened laterally and extending out from the body dorsally, each with an arcuate rima above and behind it. The wing pads reach the second abdominal segment.

Abdomen.—The first abdominal segment lacks an encircling row of spines and definite divisions setting off the lateral areas. Segments two to seven each bear a more or less complete ring of spines near the posterior third. Each segment is divided into a dorsal, two lateral and a ventral area separated by grooves. Each lateral area bears a short, truncate abdominal spiracle. The anal segment may, or may not, bear dorso-lateral and lateral combs of spines. Ventrally, in front of the anus is a row of spines running clear across in the male, but widely broken medianly in the female. The anal region is quite protuberant in the male and much less so in the female. The posterior part of the segment is composed of six heavy, sharp projections forming the pupal aster. This usually consists of two projections dorsally, a larger pair pointing dorso-laterally and another pair pointing ventrally and posteriorly.

DURATION.

The pupal period is relatively short, ranging, roughly, from one to three weeks. The writer found most of the *Chrysops* species emerging in less than two weeks after pupation, ranging from an average of 8 days for *Chrysops carbonarius* to 13 days for *C. vittatus*. *Tabanus* species require a somewhat longer period although one specimen of *T. bicolor* took only ten days and one *T. atratus* did it in 14 days. *Tabanus reinwardtii* averaged 17 days. Webb and Wells (1924) found that *T. punctifer* averaged slightly over 20 days in the pupal state. There is a considerable variation in reared pupæ, so that it is difficult to determine accurately the length of the period.

ACTIVITIES AND EMERGENCE.

The pupa is relatively quiet. At the time of pupation, it comes to lie in a vertical position, an inch or two below the surface of the soil and well above the surface of the water. The writer collected many pupæ of *Chrysops carbonarius* in very compact mud a short distance below the surface. Just before emerging, it crawls up to the surface by means of a twisting motion of the abdomen, projecting most of the thorax above the surface. The pupal case splits along the dorsum of the thorax, the fronto-ventral plate covering the head is pushed forward and the adult emerges.

When the adult first appears, the wings are very much folded and are shorter than the abdomen and the abdomen is enlarged and translucent. Soon the wings begin to enlarge and the meconium is emitted from the anal opening. This is greenish or yellowish in color, at first thick and coming rapidly and then gradually becoming thinner and dropping more slowly. From 20 to 30 minutes after emergence flight for a short distance is possible.

DESCRIPTION OF EARLY STAGES AND BIONOMICS OF SPECIES STUDIED.

Keys to Genera—Immature Stages.

EGGS.

There is no sharp line of differentiation between the eggs of different genera, although, in general, the following key will suffice for the three New York State genera in which the egg is known.

1. Usually in a single tier, lying nearly flat on the surface on which they are placed. (*C. celer* an exception)............................... *Chrysops*
   Laid at an angle to the surface, in two or more tiers.................... 2.
2. Creamy-white at time of hatching.................................. *Goniops.*
   Usually dark brown or black at time of hatching.................. *Tabanus.*

LARVÆ.

1. Body club-shaped, the thoracic segments slender, the abdominal segments robust.. *Goniops.*
   Body tapering anteriorly and posteriorly, not club-shaped................ 2.
2. Apical antennal segment much longer than the preceding segment; dorsum of thoracic segments nearly as striated as those of abdomen..... *Chrysops.*
   Apical antennal segment not longer, usually much shorter, than the preceding segment; dorsal areas smooth or striated, but those of thorax nearly or quite free from striæ.................................. *Tabanus.*

PUPÆ.

1. One spine on each side of median line on dorsum of each abdominal segment much stronger than the others in the series....................... *Goniops.*
   Spines of each series either of an almost uniform strength or at least no two spines conspicuously stronger than the others......................... 2.

2 Antennæ surpassing adjacent margin of head, head with two bristles from each dorsal tubercle *Chrysops*
Antennæ not projecting beyond lateral margin of head, head with one bristle from each dorsal tubercle *Tabanus*.

Chrysops Meigen

During the course of this study, the following species of *Chrysops* were reared from the larval to the adult stage — *callidus*, *carbonarius*, *celer*, *cuclux*, *indus*, *moechus*, *montanus*, *niger*, *striatus*, *vittatus* and *wiedemanni*

Key to Mature Larvæ of Chrysops

This key includes those species the writer has reared and several of those New York State species on which Cameron (1926) worked, the characters of the later being taken from his descriptions It must be used with caution as the pubescent areas are subject to even more variation than the color areas in the adults Those species in the group possessing a spine on the siphon are particularly difficult to separate

1 Siphon without a terminal exsertile spine 2
Siphon with a terminal exsertile spine 5
2 Anal segment slender prolegs of the pre anal segment elongate, pre anal segment dorsally with some pubescence 3
Anal segment not very slender prolegs short and rounded, pre anal segment non pubescent dorsally except for a very narrow pubescence along the dorso lateral line 4
3 Dorsum of pre anal segment distinctly non pubescent discally (Fig 5), *cuclux*
Dorsum of pre anal segment rather uniformly faintly pubescent (Fig 6), *moechus*
4 Anal segment with one or two pairs of prominent dorso lateral spots, body usually brownish green in color *carbonarius*
Anal segment with only one, small dorso lateral spot, body usually whitish or creamy in color *vittatus*
5 Posterior ring of the anal segment, dorsally, covering one third or less of the segment 6
Posterior ring of the anal segment dorsally, covering more than one third of the segment 9
6 Anal segment with one or two large dorso lateral spots, posterior ring joined widely to the anal pubescence 7
Two or three small dorso lateral spots posterior ring not joined broadly to the anal pubescence 8
7 Often two pairs of dorso lateral spots on the anal segment, tracheal trunks in the 6th and 7th segments contrasting black and opaque white *celer*
One large mitten shaped pair of dorso lateral spots on anal segment *mitis*
8 Elongate dorso lateral spots on anal segment usually joined to the posterior ring, the more dorsal of the two smaller dorso lateral spots very small and slender *striatus*
Elongate dorso lateral spots usually free from the posterior ring, the more dorsal of the remaining spots as large or larger than the other, round *excitans*
9 Anal segment with a pair of anterior dorso lateral projections from the posterior ring 10
No anterior dorso lateral projections or spots, a pair of large, clear, dorso lateral areas in the posterior ring *montanus*

10. Anterior projections from the posterior ring long and slender........*moerens*.
Anterior projections short and rounded..................................11.
11. Anal segment with no isolated pubescent spots anterior to the posterior ring..*callidus*.
One or more pairs of dorso-lateral spots anterior to the posterior ring....12.
12. Anal segment with two projections from the posterior ring between the dorsum and the anus...*niger*.
Anal segment with only one, dorso-lateral projection...................13.
13. Dorso-lateral projections from the posterior ring not abruptly narrowed apically; dorso-lateral spots large, lying close between the dorso-lateral projection and the widened lateral pubescence..............*wiedemanni*.
Dorso-lateral projections abruptly narrowed apically.................*indus*.

Chrysops callidus Osten-Sacken.

Mature larva.—Length, (living), 12–14 mm. Yellowish white or greenish; annuli brown, quite distinct; anal segment rather short and rounded; posterior pubescent ring quite broad, covering nearly half the segment dorsally and taking in the anus; a narrow anterior ring dorsally; a pair of dorso-lateral lobes anteriorly from the posterior ring and a pair of minute dorso-lateral clear spots in the posterior ring. Siphon Short, striated, with a short spine.

Pupa.—Length, 12–13 mm. The frontal carinæ prominent, rounded, the median pair divided by a deep cleft. Pre-anal fringe with about fifteen spines in the male and five or six on each side in the female. Prongs of the aster large and sharply pointed.

Range.—Ontario, Florida, Ohio, Kansas, Louisiana.

This species is abundant throughout the State from early June to early August. Occasionally, it is collected in May and late into August. Ithaca—June 16th to August 6th.

Hine, (1903), described in some detail the oviposition in this species, and Marchand, (1917), described the egg and the young larva.

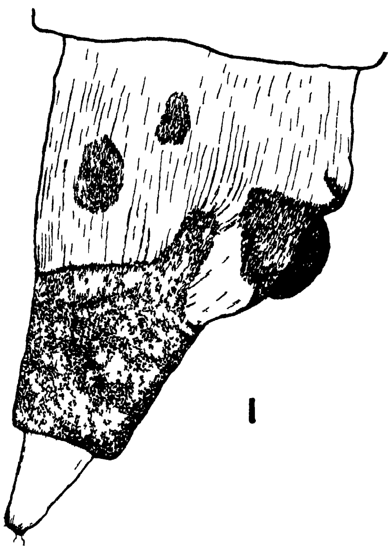
Only three larvæ were collected and positively identified during the course of this study. One was found in mud and decayed leaves of a small pond in Salisbury, Conn., the second at the margin of Dryden Pond, near Ithaca, and the third in a swamp near Ithaca. All three were found in quite unshaded localities.

As the prepupal stage was not observed, the date of pupation as given in the following table may not be accurate. It is merely the date on which the pupa was first seen. The third one emerged during the writer's absence from the laboratory from June 24th to July 1.

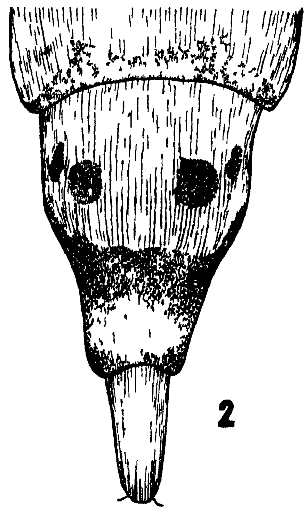
Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
April 4, 1927	L 13 mm.	....	April 28	May 7	♀
May 9, 1928	L	....	May 27	June 4	♀
June 10, 1927	L	....	June 17	June 24 July 1	♂

Chrysops carbonarius Walker.
(Figures 1, 2 and 4.)

Mature Larva.—Length, (living), 12–15 mm , (Preserved), 20–21 mm. Width, 2.5 mm. Body yellowish brown, usually with a distinct greenish tinge when living, making it olive-green; pubescence light brown; annuli only slightly darker than the integument; head reddish brown; pharyngeal capsule dark brown to black. Prothorax narrowly pubescent anteriorly, this ring being narrowest ventrally and widest laterally; posterior pubescent projections from this ring dorso-laterally, ventro-laterally, and mid-ventrally; the dorso-lateral pair extend back from the anterior margin about two-thirds the length of the segment, widen



1



2

Fig 1 *Chrysops carbonarius* Walk. Lateral view of anal segment and siphon of larva. Magnified 30 diameters.

Fig 2. *Chrysops carbonarius* Walk. Dorsal view of anal segment and siphon of larva. Magnified 21 diameters.

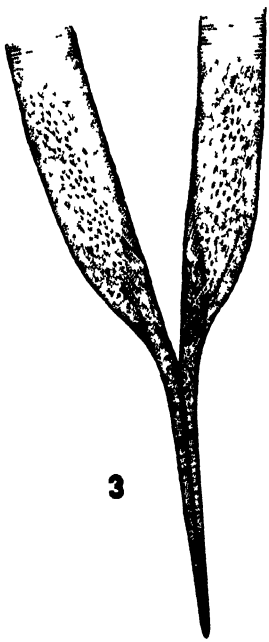
slightly posteriorly and are divided by a narrow, longitudinal hyaline line; ventro-lateral pair slender and somewhat shorter; mid-ventral line as long as the dorso-lateral pair and very slender. Mesothorax: narrow anterior annulus with posterior projections dorso-laterally, laterally, and two pairs ventro-laterally; the dorso-lateral pair is about one-third the length of the segment with its lateral margin along the dorso-lateral line and the dorsal margins nearly meeting mid-dorsally. Other projections longer, very slender and faint. Metathorax: slightly wider annulus with short, dorso-lateral projections forming a gentle curve to the anterior margin of the dorsal area and very short points at the same places as in the mesothorax. All three thoracic segments

striated throughout becoming progressively coarser from prothorax to metathorax. On each segment a narrow posterior band of very fine striation. Ventral bristles short and black. Abdomen: segments 1–7 dorsally with an anterior band of pubescence partially divided transversely by a non-pubescent area. On the first segment this transverse division is slender and nearly straight, reaching to the lateral prolegs and often broken in places by pubescence. As one proceeds posteriorly, the annuli become wider and the transverse non-pubescent area becomes shorter and crescentic with the curve anterior. Dorso-laterally, there is a small projection posteriorly from the annulus, becoming more prominent on the posterior segments, but never very long; sixth and seventh segments with a posterior annulus, the seventh with a small, pointed, dorso-lateral projection anteriorly. Lateral prolegs with fine brownish setæ and patches of pubescence dorsally and ventrally to them. Ventral pair of prolegs with brownish setæ and an irregular band of pubescence around and betwen them. On the anterior segments, the dorsal, lateral and ventral pubescent areas are joined, forming a complete ring, while on the posterior segments, this ring is broken above and below the lateral prolegs. Prolegs of moderate length. Anal segment broad at the base, tapering at the apex; dorsally with one or two pairs of prominent dorso-lateral pubescent spots; if one, it is irregular in shape, if two, the dorsal-posterior pair is larger than the more lateral, anterior pair; posterior ring about one-third the length of the segment, sometimes narrowly joined mid-ventrally to the pubescence which surrounds and covers the anus; anal and posterior pubescence nearly, or completely, joined laterally by dorsal projections of the anal pubescence meeting lateral anterior projections of the posterior ring. Integument of the abdomen striate throughout. Siphon of moderate length without pubescence or a spine at the tip; very finely striated throughout, often with hairs near the tip. Tracheal trunks quite slender, shining white to the middle of the seventh abdominal segment, posterior to which they become gray. Graber's organ usually with four pairs of black bodies.

Pupa.—Length, 11–13 mm. Width at thorax, 2.5 mm. Frontal teeth consisting of a pair of transverse carinæ flanked by a pair of small projections. The inner carinæ are quite prominent near the mid-ventral line. Rima of the prothoracic spiracle with a posterior hook which is absent in the male. Pre-anal spines in the female three or four on either side. In the male, a fringe of 12 to 16, not extending as far laterally as in the female. Pupal aster: dorsal prongs short, pointed, extending nearly parallel to each other, upward; lateral pair long and slender with slightly recurved tips, extending up and back; ventral pair intermediate in size, sharply pointed and projecting down and back. Abdominal spiracles short, dark brown, projecting somewhat posteriorly.

Range.—Canada, Maine, North Carolina, Wyoming, Colorado.

This is a common species throughout the State, appearing in the latter half of May and throughout June in the vicinity of water and woods. It is the first *Chrysops* to appear in this region. Ithaca—May 18th to June 25th. The females readily attack man and cattle.



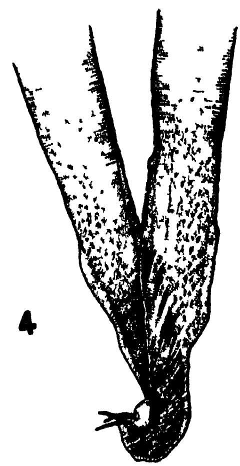


Fig 3 *Chrysops celer* O -S Dorsal view of posterior spiracle dissected from larva. Magnified 52 diameters

Fig 4 *Chrysops carbonarius* Walk Dorsal view of posterior spiracle dissected from larva. Posterior end is turned to the left. Magnified 118 diameter.

The larvæ are found in mud among dead leaves and sticks, often under the water, along the margins of streams and ponds. It is, by far, the most frequently encountered tabanid larva in this region. Over 300 larvæ and pupæ of this species were collected during the course of this study, the former ranging in size from 5 mm. to mature larvæ of 12 to 15 mm. They were collected in every month from March to November, being most abundant in April and May, rather scarce in June and again very abundant in the fall. The greatest variation in size is found in the fall when all sizes may be collected at one time and place. They apparently fed on earthworms in the laboratory

as many earthworms died, disappeared, or were found in a fragmentary condition in the jars, although the act of feeding was not observed. As is shown in the following table, several larvæ, apparently mature when collected, have remained alive and unchanged through two winters.

Pupæ were found in the field in compact mud, several feet back from the water, and just below the surface, from May 10th to May 26th. In the laboratory, they pupated from October to June with the greatest number in March and May. Those that pupated in March had been kept over the winter in the laboratory and were responding to the somewhat higher temperature, while those that pupated in May were collected the same spring and were not influenced very much by the change of environment. Larvæ collected in the field in the prepupal stage emerged eight days after pupation. The following table gives life history data on some of the larvæ reared. It is interesting to note that prepupæ were collected on May 12th in two successive years, the only date on which they were collected.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
March 19, 1927	L	March 31	April 2	April 11	♀
April 14, 1927	L	April 23	April 26	May 2	♀
" 10, 1928	L	" 24	" 26	" 3	♀
" 10, "	L	" 22	" 24	" 1	♀
" 10, "	L	" 25	" 27	" 4	♀
" 10, "	L	" 27	" 28	" 5	♀
" 10, "	L	" 21	" 22	April 29	♂
" 10, "	L	May 3	May 5	May 12	♀
May 12, 1927	Pp	" 12	" 14	" 22	♀
" 12, "	Pp	" 12	" 14	" 22	♀
" 12, "	Pp	" 12	" 14	" 21	♀
" 3, 1928	L	" 10	" 11	" 19	♀
" 4, "	L	" 8	" 10	" 17	♀
" 4, "	L	" 10	" 11	" 19	♀
" 12, "	Pp	" 12	" 13	" 22	♀
July 7, 1927	L 13 mm.	Died April 8, 1929.			
" 7, "	L 13 mm.	Died March 19, 1929.			
" 7, "	L 15 mm.	Died May 20, 1929.			
" 16, "	L 13 mm.		March 26	April 5	♀
" 16, "	L 14 mm.		April 17	" 21	♂
" 29, "	L 15 mm.	April 10, 1929. Died April 11.			
August 30, 1926	L	Feb. 12	Feb. 17	March 3	♀
" 30, "	L	" 26	March 2	" 11	♂
" 30, "	L	March 12	" 17	" 24	♀
Sept. 24, "	L	Feb. 26	" 3	" 13	♀
" 1, 1927	L 13 mm.		Oct. 27	Oct. 31	♂
Oct. 6, 1926	L	Feb. 19	Feb. 22	March 6	♀
" 6, "	L	March 12	March 14	" 23	♂

Chrysops celer Osten-Sacken.
(Figures 3 and 9.)

Mature Larva.—Length, (living), 14–16 mm., (preserved), 20–22 mm. Width, 2.5–3 mm. Body pale, creamy white; pubescence of anal segment dark brown; annuli pale brown; head brown, the slender anterior portion of the pharyngeal capsule yellowish-orange, the wider posterior portion dark brown. Markings of the thoracic and first seven abdominal segments much like those of *C. carbonarius* but slightly paler and less extensive. The dorso-lateral projections of the prothorax are smaller. Ventral thoracic bristles extremely slender. Annuli of abdominal segments very pale and indistinct. Striæ moderately coarse, becoming coarser posteriorly. The posterior ring of the seventh abdominal segment lacks definite, anterior projecting, dorso-lateral lines. Anal segment broad basally and constricts rather abruptly to form a narrow apex. Dorsally, the posterior pubescent ring is confined to this narrow portion, about one-third the length of the segment, and it is usually slightly curved forward in the center; laterally and ventrally, it becomes much wider, covering the anus. There is sometimes left a pair of ventro-lateral clear spots in the wide ring. The dorso-lateral region may contain two pairs of distinct longitudinal pubescent spots, the lateral one slightly smaller and anterior; these spots may be fused forming one large pair; this large pair may be joined anteriorly to the lateral pubescence or it may also be joined posteriorly to the posterior ring, leaving only a small clear area between it and the lateral pubescence. There is an irregular band, or a pair of pubescent spots dorsally along the anterior margin and this is often joined to the dorso-lateral spots. Prolegs quite short. Siphon rather short, heavy, without pubescence and very finely striated, often with a few hairs at tip. A very strong excsrtile spine is present, reddish in color. Tracheal trunks rather heavy and white except for the posterior part. From the region of the posterior transverse trunk in the 7th abdominal segment back to the middle of the anal segment, the tracheal trunks are dark brown or nearly black; from this point, to the joining of the two trunks to form the spine, they are opaque, creamy white. This character can be seen most easily in the living larva and it is very distinctive. Graber's organ usually with four pairs of bodies. The combination of the light color, the markings of the anal segment, the spine from the siphon and the color of the tracheal trunks will serve to identify this species.

Pupa.—Length, 12–14 mm. Median frontal carinæ only slightly protruding, broad, rounded; lateral frontal carinæ very small. Preanal fringe in male of fifteen or more spines, in the female usually with four spines on each side. Aster with large, sharp prongs.

Range.—Ontario, Quebec, Ohio, North Carolina.

This species is very similar in habits to *carbonarius* and is likewise one of the earlier forms. It is moderately abundant throughout the State from late May to early July. Ithaca—May 30th to June 29th. It attacks man and cattle readily.

Hine (1903a) observed oviposition in this species and found that it placed its eggs in layers, one above the other, as in *Tabanus*.

The larvæ are found in the muddy margins of ponds and sluggish woodland streams among decaying vegetation. Over sixty larvæ and one pupa were collected. They were found from March to November, the majority of them being collected in May and July. A number of them were lost, as they are very active and crawled out of the jelly glasses on which the covers were not secure. They apparently fed on earthworms put in the jars.

On May 12th, a prepupa was collected in friable mud some distance from the water, exactly a year later two more were collected in the same place, and on June 19th a pupa was found. Pupation occurred in the laboratory from April 13th to June 19th, most of it occurring in May. The average length of the pupal period, in the laboratory, was 11 days. In no case was it less than 8 days.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
March 26, 1927	L	April 10	April 13	April 21	♀
April 6, "	L	" 22	" 24	May 3	♀
May 12, "	Pp	May 12	May 14	" 22	♂
" 12, 1928	Pp	" 12	" 16	" 27	♂
" 12, "	Pp	" 12	" 13	" 23	♂
" 12, "	L	" 22	" 29	June 10	♀
" 12, "	L	" 13	" 16	May 27	♂
June 19, "	P		June 19	June 26	♀

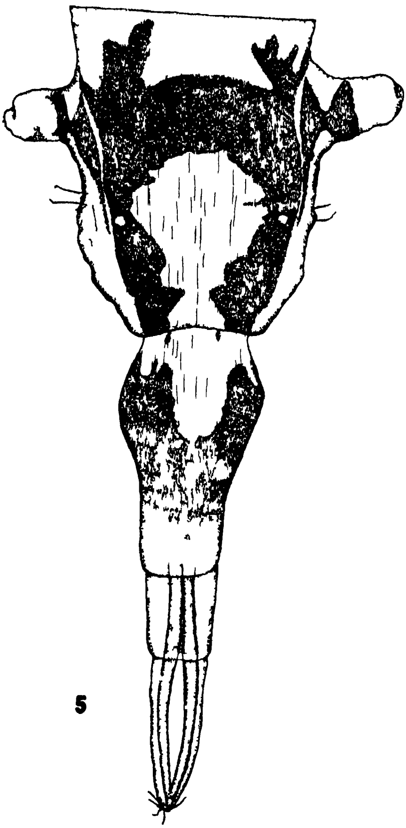
Chrysops cuclux Whitney.

(Figure 5.)

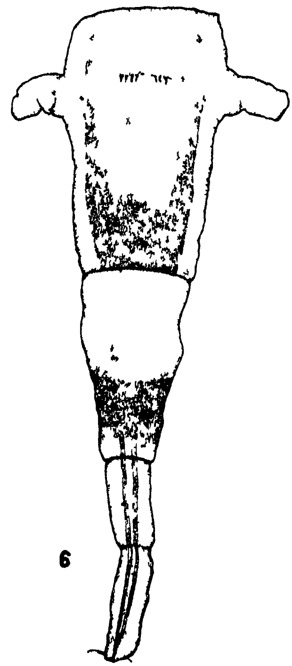
Mature Larva.—Length, (living), 12–14 mm., (preserved), 17–19 mm. General color yellowish brown; pubescence rather dark brown; head pale brown, the pharyngeal capsule black. Thoracic segments with anterior pubescent annuli and projections posteriorly from it along the dorso-lateral, lateral, ventro-lateral and median lines as in *carbonarius* and others of this group; the dorso-lateral spots on the prothorax elongate and distinct; annuli of the abdominal segments becoming wider posteriorly; sixth abdominal segment with little, if any, pubescence dorsally; pre-anal segment pubescent dorsally except for a distinct clear area discally; the dorso-lateral pubescence on this segment much wider than it is ever found in *carbonarius*. Lateral and ventral prolegs long, projecting at right angles, the posterior pairs longest and lacking setæ; these are nearly as long as in *moechus* but in crawling, they are pulled nearly directly in and not bent backward. Anal segment long and slender, with a wide posterior ring nearly covering the anus; a pair of dorso-lateral projections meeting the dorso-lateral

pubescence of the pre-anal segment. Siphon long and slender with a slight pubescence and no exsertile spine; tracheal trunks very slender, distinctly separated in the siphon up to the tip. Graber's organ compact with usually four pairs of black bodies

The larva of this species can be readily determined by the markings of the pre-anal segment and the shape of the prolegs and anal segment.



5



6

Fig 5. *Chrysops cuclux* Whitn Dorsal view of pre-anal and anal segments and of siphon of larva Magnified 20 diameters.

Fig 6 *Chrysops moechus* O S Dorsal view of pre-anal and anal segments and of siphon of larva Magnified 15 diameters

Pupa.—Female: Length, 12 mm. Median frontal carinæ rather prominent, narrow; lateral frontal carinæ small. Pre-anal spines four or five on each side; aster with a broad median surface, the prongs large, the dorsal and lateral prongs on each side somewhat joined at the base; apices sharp, sligh tly curved.

Range.—Ontario, Nova Scotia, New York, Massachusetts.

This species is moderately abundant in May and June over most of the State. It has been collected at Ithaca, but not by the writer.

Larvæ were collected by month, as follows: May, 1; July, 9; August, 3; September, 11; October, 2; November, 1; a total of 27. Only one of these has emerged at the time this is written, but the larva is so distinctive that identification is not apt to be incorrect. They were all found in the very wet mud of sluggish streams or at the margin of artificial ponds.

The one specimen that completed its life cycle was collected on May 4th, found to have pupated on May 26th, and emerged June first, a female.

Chrysops indus Osten-Sacken.

Mature Larva.—Length, (living), 13-14 mm. General color pale, yellowish white; annuli pale brown, indistinct; striæ of thorax and abdomen quite distinct. Prolegs short, rounded, provided with short setæ. Anal segment with a rather broad posterior pubescent ring with a pair of slender, dorso-lateral projections narrowing apically, and a pair of spots anterior and lateral to them; pubescence covering the anus ventrally; a pair of minute, dorso-lateral hyaline spots in the posterior ring. Siphon short and rounded with a very short spine. Tracheal trunks heavy.

Pupa.—Length, 12-14 mm. Frontal carinæ quite prominent, the median pair rather broad and separated by a distinct cleft, the lateral pair smaller and pointing somewhat laterally. Pre-anal fringe in female with four long spines on each side; in the male, about 15 in the entire row. Aster with large prongs; dorsal pair distinctly separated at the base, and curved laterally; lateral pair large and close to the dorsal pair; the ventral pair pointing somewhat to the sides.

Range.—Ontario, Quebec, Iowa, New York, New Jersey.

This species appears early in June throughout most of the State and continues through to late July or early August. It is one of the most frequently encountered species during June and July, and is a persistent pest of man, cattle and horses. Ithaca—June 14th to July 22nd.

Hine (1903a) observed this species ovipositing along the margin of a small lake, the eggs being placed in single layers on grass blades over the water. He collected males near where the females were ovipositing and on the flowers of *Cornus*.

This is one of the typical semi-aquatic species in the larval state. The writer has reared four males and one female of this species from larvæ, and one male from a pupa collected in

the field. The larvæ were all found in the mud at the margins of a small pond and a backwater pool.

One pupa was collected in the mud of the outlet of Green Lake, near Tully, N. Y., on June 12th and on June 18th a male emerged. As may be seen in the following table, pupation in the laboratory occurred late in May and early in June and the pupal period averaged about 12 days.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
April 22, 1926	L			June 13	♀
May 10, 1927	L	May 24	May 29	" 10	♂
" 10, "	L	" 31	June 2	" 13	♂
" 10, "	L	" 16	May 18	" 1	♂
June 12, "	P		June 12	" 18	♂

Chrysops moechus Osten-Sacken.

(Figure 6.)

Mature Larva.—Length, (living), 14–15 mm., (preserved), 17–18 mm. Width, 1.5 mm. A very slender larva with prominent prolegs. Body pale yellowish or greenish brown, becoming darker on the posterior segments. Head light brown, the pharyngeal capsule dark brown. Thoracic segments with an irregular anterior band of faint pubescence, widest on the prothorax where it covers about half the segment and narrower on the other segments. Striæ of the thoracic segments very fine. Abdomen: first to fourth segments usually clear, the annuli becoming wider posteriorly; fifth segment dorsally with only a large discal spot clear, the rest pubescence; sixth and seventh nearly uniformly covered with fine pubescence; no distinct clear patch discally on the dorsum of the seventh segment. Striæ of the abdomen very fine; dorsal prolegs fused into one rather prominent transverse ridge, the lateral prolegs very prominent becoming longer posteriorly and extending at right angles; when alive, they bend backward in crawling; ventral pair of prolegs also prominent and close together; the setæ which are abundant on the shorter anterior prolegs are lacking on the larger posterior prolegs. Anal segment long and slender, very narrow and attenuated posteriorly; fine pubescence over the whole segment, this being thicker in a band around the middle of the segment just posterior to the anus and at the region of the narrowing of the segment. Siphon long and slender, faintly pubescent, without a spine but often with long hairs. Tracheal trunks extremely slender, white anteriorly to the anal segment and brown posteriorly, distinctly separated in the siphon until they reach the tip. Graber's organ with three or four bodies.

Pupa.—Length, 11–12 mm. Median carinæ of the front of the head prominent, angular, the lateral pair smaller but also distinctly projecting. Pre-anal fringe in the female consisting of three or four spines on each side and in the male of about 12 spines in all. Pupal aster with a rather broad median part and short spines.

Range.—Michigan, New York, Ohio, Virginia, Georgia.

This species is moderately abundant throughout the State south of the Adirondacks in late June and early July. Ithaca—July 2 to 30th. Hine, (1903), observed the females ovipositing on foliage overhanging a mill race on June 4th.

Twelve larvæ were collected in May of 1927 and May, June, July and September of 1928. They were all found in very wet mud, often under the water, at the margin of a small artificial lake and at the margin of a muddy backwater above a dam. They are very active larvæ. No pupæ or prepupæ were collected in the field. Pupation occurred in the laboratory the last week of May with one exception in June. The length of the pupal period was very irregular, ranging from 10 to 15 days. The following table gives the life history data of those that emerged.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 7, 1927	L 16 mm.		May 31	June 8	♀
" 7, "	L 16 mm.		" 31	" 6	♀
" 8, "	L	May 25	" 27	" 6	♂
" 4, 1928	L	" 25	" 29	" 11	♂
June 19, "	L		June 30	July 9	♂

Chrysops montanus Osten-Sacken.

Mature Larva.—Length, (living), 12–14 mm., (preserved), 14–16 mm. Very pale yellowish white; annuli very little darker; head capsule brownish; prothorax very finely striated; rest of thorax and abdomen striate, the striæ wider apart anteriorly (except for prothorax) than posteriorly. Pre-anal segment usually with pubescence along the dorso-lateral lines. Abdominal prolegs rather short, rounded. Anal segment rather short and rounded, a wide posterior pubescent ring reaching to the front of the anus, in which lie a pair of large dorso-lateral clear spots and often a pair of large ventro-lateral clear spots. Siphon rather short and rounded, striate, with a prominent, exsertile spine.

Pupa.—Length, 10–12 mm. Median frontal carinæ large, wider medianly than laterally and separated by a very narrow cleft; lateral carinæ also large and usually distinctly separated from the median pair. Pre-anal fringe in female with about four spines on each side somewhat joined basally in a protuberance; in the male, 12 to 15 in all. Aster with large prongs, the two upper pairs with the tips curved downward slightly; the lower pair very acutely pointed.

Range.—Quebec, Vermont, Ohio, Illinois, Maryland.

This species is rarely found except in the vicinity of lakes or ponds, at which places it may become quite abundant. It has not been recorded from Ithaca. On July 7th, the writer

collected one at Spencer Lake and on August 4th, four at Cayuta Lake, both about 14 miles from Ithaca. At the latter place, they flew to our boat when some distance from the shore, to attack us. It has been collected throughout the State from late June to early August. Hine (1903a) also found it partial to lakes and collected males by sweeping plants along the margin of a lake.

The larvæ were collected near North Fairhaven, N. Y., on the shore of a small pond close to Lake Ontario. The pond was separated from the lake by a narrow strip of beach and the larvæ were found right at the water's edge in very coarse sand saturated with water. Eighteen were collected in less than ten minutes and without moving from one spot. The next day, on returning to the laboratory, it was found that several of them had formed prepupæ. On June 24th, the writer was called away from the laboratory, at which time most of them had pupated and on returning July 1st, all except one had emerged, and that emerged the following day. The pupal period was, therefore, close to eight days. The following table gives the life history data on those that emerged. The date of emergence is not strictly accurate as some may have emerged previous to this date.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
June 15, 1927	L		June 16	July 1	♂
" 15, "	L	June 16	" 18	" 1	♂
" 15, "	L	" 16	" 19	" 1	♂
" 15, "	L	" 18	" 21	" 1	♂
" 15, "	L		" 23	" 1	♀
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♀
" 15, "	L		" 23	" 1	♀
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♀
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♂
" 15, "	L		" 23	" 1	♂
" 15, "	L	June 23		" 2	♀

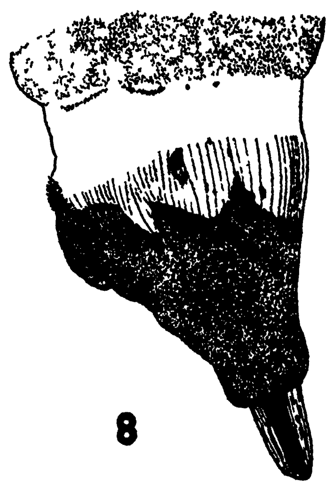
Chrysops niger Macquart.

(Figure 7.)

Mature Larva.—Length, (living), 10–11 mm., (preserved), 13–14 mm. Width, 1.8 mm. A pale yellowish white larva; pubescence brown; head pale, the skeletal portion of the pharyngeal capsule darker brown. Prothorax with anterior half finely pubescent; striæ fine. Mesothorax with a rather narrow ring of pubescence, wider laterally; the striæ fine

laterally, coarse dorsally and ventrally Metathorax much like the mesothorax ventral setæ on the thoracic segments very fine. Abdomen: annuli indistinct, dorsally consisting of a double transverse row of scattered pubescence and setæ becoming farther divided posteriorly; striæ of abdomen coarse dorsally and ventrally, fine laterally; prolegs rather short, clothed with light setæ, the dorsal pair joined in one transverse ridge Anal segment short, stout, sub-conical; scattered pubescence along the anterior margin, dorsally; posterior ring narrowest dorsally covering the narrow part of the segment; ventrally, it reaches the anus and joins the anal pubescence the full width of the anus;

7



8

Fig 7. *Chrysops niger* Macq. Lateral view of anal segment and siphon of larva. Magnified 44 diameters

Fig 8 *Chrysops vittatus* Wied Lateral view of anal segment and siphon of larva Magnified 32 diameters

dorso-laterally, a pair of prominent anterior projections, often of darker pubescence; just anterior and lateral to this, a round, dorso-lateral spot; these two are often joined and the connection between the projection and the posterior ring broken, giving a hook-shaped dorso-lateral spot; laterally, there is a prominent anterior projection, often swollen at the end and separated from the anal pubescence by a distinct posterior projection of the clear area; setæ very prominent around the apex of the anal segment and to either side of the anus. Siphon heavy, finely striated, faintly pubescent at base with a prominent, slender spine. Tracheal trunks heavy, white. Graber's organ with three or four pairs of bodies

This species is much like *C. wiedemanni* Kröb. but the posterior ring is separated from the anal pubescence laterally and there are no light dorso-lateral spots in the posterior ring.

Pupa.—Length, 11–12 mm. Frontal carinæ absent, the frontal plate rounded with only the slightest indication of a pair of protuberances. Four or five spines to either side in the pre-anal fringe of the female; male with about 15 spines in the whole row. Aster considerably wider transversely than dorso-ventrally; the dorsal prongs run parallel to each other, the lateral pair extend widely to the sides, and the ventral pair are widely separated; all the prongs are separated from each other to some extent. The width of the pupal aster and the non-carinated front serve to distinguish this species from any other *Chrysops* pupa of which the writer knows.

Range.—Nova Scotia, Maine, New York, Illinois, Tennessee, Georgia, Virginia.

A common species throughout the State from late May to early August. It appears shortly after *carbonarius* and attacks man, cattle and horses. Ithaca—May 30th to July 10th.

The larvæ of this species are found in wet mud usually in unshaded places. They were collected from May 13th to June 6th, eight of which were found in a boggy meadow fed by springs, one at the margin of a swamp by a roadside, and another in a creek bank.

Pupation occurred in the laboratory from May 18th to June 12th. The pupal period is long, about 14 days, and one remained as a pupa 17 days. The following table shows the variation, although the pre-pupal period was noted in only three. The pupal period of the others might have been even longer.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 13, 1928	L	May 27	May 29	June 11	♀
" 13, "	L		" 25	" 8	♂
" 13, "	L		" 27	" 7	♂
" 13, "	L		June 3	" 10	♀
" 13, "	L	May 14	May 18	" 1	♂
" 13, "	L		" 22	" 8	♀
" 27, "	L	June 8	June 12	" 26	♀
June 6, 1927	L		" 11	" 19	♀

Chrysops striatus Osten-Sacken.

Mature Larva.—Length, (living), 12–13 mm. Pale yellowish or greenish-white; head and pharyngeal capsule pale brown; annuli pale and rather indistinct. Prolegs short with fine setæ. Anal segment with a narrow posterior pubescent ring and markings as follows: (1) a pair of spots, joined to each other, close to the median line at the extreme base of the segment; (2) a pair of very small linear spots slightly more laterally and half way between the base and the apex of the segment; (3) nearly laterally, somewhat anterior to the latter spots, a pair of larger spots, somewhat linear and pointing antero-medianly; (4) a pair

of slender lateral lines running forward past the widest part of the segment and loosely joined to the posterior ring; (5) a spot to each side of the anus; anus with a slight ring of pubescence around it; the anal pubescence not joined to the posterior ring. Tracheal trunks large. Siphon short, striated, with a very short spine.

Pupa.—Length, 10–12 mm. Median frontal carinæ of moderate size, rounded; lateral pair scarcely visible. Pre-anal fringe in the female with five long spines to either side. Aster in the female with all the prongs very sharp, the dorsal pair close together, the ventral pair pointing nearly straight back; in the male, the dorsal and lateral pairs have slightly recurved tips and the prongs of the dorsal pair are quite widely separated.

Range.—Ontario, Maine, Illinois, New Jersey, Mexico, Louisiana.

This species is found throughout the State from late June to late August, being particularly abundant along the shore of Lake Ontario. It is only infrequently encountered in the vicinity of Ithaca, the writer having collected only three adults during the course of this study, in the latter part of July.

Three larvæ of this species were collected and reared to the adult state. They were all collected in mud, one near Canaan, Conn., and two others at Big Lake, Tully, N. Y. The following table gives the life history, as far as it was recorded, of these three.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
June 30, 1927	L 13 mm.	June 12	June 13	June 19	♀
" 12, 1928	L		" 26	" 28	♂
" 12, "	L 12 mm.		" 29	" 30	♂

Chrysops vittatus Wiedemann.

(Figure 8.)

Mature Larva.—Length, (living), 10–12 mm., (preserved), 16–17 mm. Width, 1.6 mm. Body creamy white, the annular pubescence very pale anteriorly, becoming slightly darker posteriorly; anal pubescence dark brown. Head and posterior part of the pharyngeal capsule brown. Prothorax finely striated, extremely so laterally; pubescence covering about three-fourths of the segment anteriorly, being slightly narrower dorsally. Mesothorax with anterior portion of the clear area coarsely striated, posterior part finely striated; dorsally, the pubescence is very narrow at the median line, running back to about one-half the length of the segment at the dorso-lateral line; laterally, the pubescent area is slightly narrower than the widest part of the dorsal pubescent area and is fairly uniform in length the width of the area; ventrally, the pubescent area is still narrower with a constriction each side of the median line leaving a rounded swelling medianly.

Striæ and the pubescent pattern of metathorax as in the mesothorax, but as the segment is larger in diameter, the dorsal and ventral angles are not as acute; ventral setæ very fine, black, those of the prothorax in the pubescent area. Abdomen: annuli very pale, the dorsal transverse non-pubescent area becoming wider and shorter posteriorly; the dorsal prolegs fused into one, slightly raised transverse ridge; lateral and ventral prolegs moderately prominent, clothed with short, pale setæ. Anal segment with the posterior, slender part elongate; the dark brown posterior ring covers about one-half the segment middorsally with a pair of triangular anterior projections dorso-laterally; ventrally, it covers the anal region; often a pair of small linear spots just lateral and anterior to the triangular projections of the posterior part of the posterior ring; a narrow anterior annulus dorsally; the narrow posterior part of the posterior ring often paler than the anterior part; siphon very slender, non-pubescent, finely striated, without spine but often with a few hairs near the tip. Tracheal trunks slender, pale brown in the anal segment and siphon, the rest white. Graber's organ usually with four pairs of bodies.

Pupa.—Length, 10-12 mm. Frontal carinæ not very prominent, the median and lateral pairs both rounded, the latter somewhat smaller. Pre-anal fringe with four or five spines on each side in the female; in the male, about 15 spines all together. Aster; dorsal prongs small, sharply pointed; lateral pair largest, slightly recurved.

Range.—Eastern North America from Quebec to Florida and west to Kansas and Iowa.

This is the most abundant *Chrysops* in the vicinity of Ithaca and it causes more discomfort to one walking in the woods than all the other species combined. It also is very troublesome to cattle and horses. Hine, (1903a), writes, "The most abundant and widespread species in this section. The females are troublesome to stock and are commonly observed on horses and cattle with their abdomens filled with blood. The males have been procured along the margins of ponds and on various kinds of flowers." It is found throughout the state from the latter part of June through August. At Ithaca, it is particularly abundant in July. Ithaca—June 25th to August 29th.

The larvæ are found in wet mud at the margins of ponds and streams. About fifty were collected during the course of this study in a number of different places in the vicinity of Ithaca and in northwestern Connecticut. The majority of places were quite shaded, but several were not. They were found in every month from May to November, being most abundant in May, August and September.

The larva of this species was described by Hart in 1895, the first *Chrysops* larva to be described. He found it in some abundance in the mud and matted vegetation of a weedy, swampy little stream. His description of the larva accords with the specimens the writer has obtained, with one exception. He wrote, "Respiratory tube whitish, *spine sometimes projecting.*" We have carefully examined all the larvæ and larval exuviæ obtained and have found them all to possess the compressed type of posterior spiracle joined firmly to the integument at the end of the siphon.

Pupation in the laboratory occurred from March to July, most of it in late May and June. One prepupa was collected in the field on May 29th and a male emerged from it June 7th. The average pupal period in the laboratory was 13 days, with a range of from 8 to 18 days. This variation did not correspond to variation in temperature or in the time of pupation. The following table gives the rearing data of those larvæ in which the prepupal stage was noted and of several others of interest.

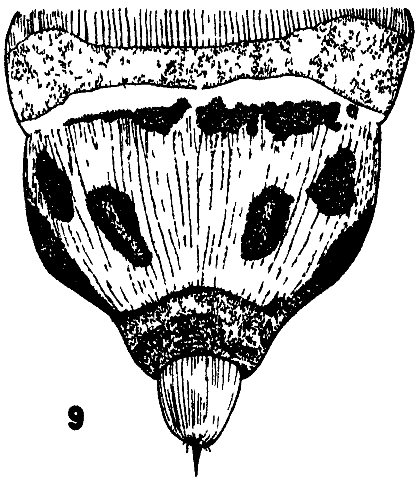
Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 5, 1926	L	June 15	June 19	July 3	♂
" 5, "	L	" 19	" 21	" 4	♂
" 29, 1927	Pp	May 29	May 31	June 7	♂
" 4, 1928	L	June 1	June 2	" 14	♀
" 12, "	L	" 2	" 3	" 16	♀
" 13, "	L	" 1	" 2	" 16	♀
" 13, "	L	May 29	" 1	" 13	♂
" 13, "	P		May 27	" 11	♂
June 16, 1926	L	June 28	June 30	July 10	♂
" 16, "	L	" 28	" 30	" 12	♀
" 6, 1927	L	" 11	" 14	" 1	♀
" 30, "	L	" 11	" 13	June 23	♂
July 26, "	L	Died May 31, 1929.			
Aug. 22, "	L	May 23	May 29	June 12	♂
Sept. 17, "	L	" 17	" 18	" 2	♀
" 17, "	L	April 8	April 11	April 22	♀
Oct. 6, 1926	L	Mar. 12	Mar. 17	Mar. 27	♀
Nov. 3, "	L			May 8	♀

Chrysops wiedemanni Kröber.

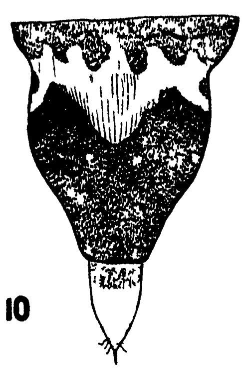
(Figure 10.)

Mature Larva.—Length, (living), 10–12 mm., (preserved), 13–15 mm. Width, 2 mm. A pale yellowish white larva; annuli pale brown, indistinct, the pubescence of the anal segment darker brown; head pale, part of the pharyngeal capsule brown. Anterior half of prothorax with pale pubescence; striæ very fine; anterior pale annuli of the meso- and metathorax rather narrow dorsally, wider laterally. Abdomen: striæ increasingly coarse from anterior to posterior; the annuli very

sparcely pubescent; lateral and ventral prolegs moderately projecting, clothed with pale setæ; anal segment rather short, sub-conical; dorsum with a row of four pubescent spots along the anterior margin, the median pair sometimes fused; the posterior pubescent ring covers about one-half the segment mid-dorsally and becomes longer to cover the anus ventrally; a pair of small, anterior, dorso-lateral projections from it often darker in color; a pair of lateral and ventro-lateral lobes also present in many specimens; a distinct pair of dorso-lateral spots anterior and lateral to the dorso-lateral projections from the posterior ring; ventrally the posterior ring is pale except in the vicinity of the anus;



9



10

Fig 9. *Chrysops celer* O.-S. Dorsal view of anal segment and siphon of larva. Magnified 21 diameters.

Fig 10. *Chrysops wiedemanni* Krob. Dorsal view of anal segment and of siphon of larva. Maginfied 15 diameters.

often a pair of minute, clear, dorso-lateral spots in the posterior ring. Siphon rather short, finely striated, pubescent at the base, with a short, sharp, exsertile spine and often a few hairs at the tip. Graber's organ usually with four bodies.

Pupa.—Length, 11–12 mm. The four frontal carinæ very prominent, somewhat rounded. Pre-anal fringe with 12–15 spines in the male, 3–5 on each side in the female. Prongs of the aster prominent.

Range.—Ontario, Quebec, Kansas, Ohio, North Carolina, Louisiana, Georgia.

This is a common species throughout the State from late June to late August. Ithaca—June 26th to August 15th. It seems partial to woodland and readily attacks man and animals

in wooded regions. Hine (1903a) collected the males by sweeping along the margins of artificial lakes.

About sixty larvæ and pupæ were collected in ten different places in central New York and Northwestern Connecticut. They were found both in the muddy banks of streams and at the margins of small ponds, but always in very wet places. The majority of them were found in May and June, but they were also collected on into September.

One pupa was collected on June 19th in association with a number of larvæ of the same species, in very wet mud, among cat-tails at the margin of a small pond. Four more pupæ were collected on June 29th in a boggy meadow. Pupation in the laboratory occurred from April 8th to July 24th, the majority in late June and early July. The pupal period in the laboratory averaged 13 days. The following table gives the life history data on those larvæ in which the pre-pupal stage was recorded and of the five pupæ collected in the field.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 13, 1928	L	June 8	June 12	June 26	♂
" 13, "	L	May 31	" 1	" 15	♂
" 13, "	L	June 11	" 13	" 26	♀
" 13, "	L	May 31	" 1	" 14	♂
" 13, "	L	June 11	" 13	" 26	♂
" 27, "	L	" 14	" 15	" 26	♂
" 27, "	L	" 11	" 13	" 26	♂
" 27, "	L	" 13	" 15	" 26	♀
" 27, "	L	" 13	" 15	" 26	♂
" 27, "	L	" 13	" 14	" 26	♂
June 5, 1927	L	" 17	" 20	July 1	♀
" 30, "	L	July 8	July 11	" 16	♂
" 19, 1928	P		June 19	June 30	♂
" 29, "	P		" 29	July 7	♂
" 29, "	P		" 29	" 2	♀
" 29, "	P		" 29	" 1	♂
" 29, "	P		" 29	" 4	♂
Sept. 3, 1927	L	May 20	May 21	June 7	♀

Goniops Aldrich.

Goniops chrysocoma Osten-Sacken.

Larva.—The larva of this species has been described in such detail by McAtee (1911), both in the first instar and when mature, that it will not be necessary for the writer to redescribe it here.

Pupa.—This is also described in great detail by McAtee, in the same paper.

Range.—New York, Ohio, Florida.

This species is infrequently collected in July and August throughout the southern half of the State, its actual abundance being difficult to determine because of its retiring habits. It has never been known to feed on blood. Ithaca—August 8th to 15th.

A female was discovered with her egg mass on August 9, 1926 in a small clump of *Fagus* at the edge of the woods. The ground was quite dry then. The attention of the writer was drawn to the fly by the rattle of her wings and she was collected before the egg mass was seen.

The egg mass, which was on the underside of a leaf about a foot from the ground, was taken to the laboratory. The mass was composed of three layers of creamy white eggs about 7 by 8 mm. in diameter and 4 mm. high. On August 19th at one o'clock, the larvæ began to emerge. It took about three minutes for an individual larva to free itself from the egg.

The larvæ were put in vials with soil from the place the eggs were collected and fed with small insect larvæ and bits of worm. but gradually they died off. Cast skins were found and several reached a length, (preserved), of 3 mm., but by February 17th all of them had died. They were always extremely sluggish.

On November 22, 1927, Dr. R. D. Harwood collected and preserved two larvæ, 5 and 15 mm. in length, of this species. They were found in leaf mold on the side of a steep, wooded hill.

For a further discussion of the biology of this peculiar fly, one should consult the papers of Walton (1908) and McAtee (1911).

Tabanus Linné.

During the course of this study, *Tabanus atratus* was reared from the egg to the adult and *bicolor*, *minusculus*, *nivosus*, *reinwardtii* and *trepidus* from larva to adult.

Key to Mature Larvæ.

This key includes those species reared by the writer and some other New York State species described by Hart (1895), Hine (1906), and Cameron (1926). Like the key to the *Chrysops* larvæ, it must be used with caution.

1. Anterior ring of prothorax widened laterally, covering more than half the lateral areas. (Fig. 12) .... 2.
   Anterior ring of prothorax not distinctly widened laterally. (Fig. 11) .... 5.
2. Abdominal segments 1–7 with a dorsal median pubescent projection posteriorly from the anterior ring .... 3.
   Abdominal segments without a dorsal median pubescent projection from the anterior annulus .... 4.
3. Pubescent areas dark brown; no terminal exsertile spine; dorso-lateral projections of mesothorax swollen posteriorly .... *atratus*.
   Pubescent areas paler; usually a terminal exsertile spine showing; dorso-lateral projections of mesothorax not swollen posteriorly .... *stygius*.
4. Anterior abdominal annuli broad, a transverse non-pubescent area dorsally in each one; a distinct posterior annulus on most of the abdominal segments, especially the seventh .... *reinwardtii*.
   Anterior abdominal annuli narrow, with no transverse non-pubescent area dorsally in each one; posterior annuli of abdominal segments very narrow and irregular .... *vivax*.
5. Posterior ring of anal segment absent or vestigial .... 6.
   Posterior ring of anal segment narrow but distinct .... 8.
6. A lateral pubescent spot above the anus; annuli of meso- and metathorax and abdominal segments scarcely visible .... *nivosus*.
   No lateral pubescent spot above the anus; annuli of abdominal segments slender but quite distinct .... 7.
7. Mature larva 17–19 mm. in length alive, 20–22 mm. preserved .... *minusculus*.
   Mature larva 22–25 mm. in length alive, 26–28 mm. preserved .... *trepidus*.
8. Elongate dorso-lateral, posterior, pubescent projections from the anterior ring of the mesothorax .... *lineola*.
   No elongate dorso-lateral posterior, pubescent projections from the anterior ring of the mesothorax .... 9.
9. Anal segment with a distinct anterior ring of pubescence including the anus with two posterior lateral projections from it .... *costalis*.
   Anal segment without a distinct anterior ring .... 10.
10. Anal segment with slender, longitudinal pubescent spots dorsally and laterally .... *bicolor*.
    Anal segment without dorso-lateral spots, sometimes with a small, round, lateral spot .... *septentrionalis*.

Tabanus atratus Fabricius.

Larva.—Newly hatched. Length, (alive), 2.5 mm.; (preserved), 3–3.5 mm. General color white; annuli pale brown; head light brown, the pharyngeal capsule dark. Prothorax with pale brown dorso-lateral pubescent projections from the anterior ring. Thorax and abdomen with tufts of bristles between the annuli and long setæ on the

prolegs. Anus dark with faint brown pubescence on each side. Graber's organ with one pair of bodies.

Mature. Length, (alive), 40–50 mm.; (preserved), 50–60 mm. Body hyaline with dark brown pubescent markings; mandibles and pharyngeal capsule black. Prothorax with an anterior, reddish brown annulus; from this runs a dorso-lateral longitudinal line about three-fourths the length of the segment and swollen behind; lateral areas pubescent over the anterior two-thirds or more of the segment; a ventro-median pubescent line from the posterior ring as long as the lateral pubescence; mesothorax with dorso-lateral, two lateral, and a ventro-lateral pair of projections back from the anterior ring, fused at the base laterally and not quite reaching the posterior margin of the segment; metathorax with same longitudinal lines as in the thorax, but longer and more slender, and a narrow posterior ring more or less joins them. Abdominal segments 1–7 with dorsal median projections from the anterior annulus; on the median segments, they nearly extend the full length and are often expanded posteriorly; dorso-lateral lines on abdominal segments 1–7, often broken on the median segments; indications of lateral and ventro-lateral lines, especially on the seventh segment. Dorsal prolegs short and rounded, lateral, ventro-lateral and ventral pairs more prominent, although not elongate, and provided with pale setæ. Striæ sparse dorsally and ventrally, very fine and close together laterally. Anal segment with a narrow anterior ring and a pair of small dorso-lateral spots joined to it; posterior to these, a pair of dorso-lateral spots formed by the fusion of two rather longitudinal spots; posterior ring rather narrow, joined to the anal pubescence by lateral bands of pubescence. Nearly all the longitudinal lines of the body are bisected longitudinally by a line of small non-pubescent spots. Siphon short and finely striated without a spine. Tracheal trunks large, white to the middle of the 7th abdominal segment, black dorsally posterior to that; they unite in a vertical spiracular slit.

This larva has been described previously by Walsh (1863), Riley (1870), Hart (1895) and Hine (1906).

Male Pupa.—Length, 30–35 mm.; width, 7–8 mm. Median frontal carinæ prominent, overhanging the median cleft; lateral frontal carinæ broad and less prominent; antennæ and tubercles darker than the rest of the body. Fringes of spines on abdominal segments consisting of a row of short spines and just posterior to them a row of long spines, both longer on the posterior segments; long spines of dorsum of 7th abdominal segment consisting of one to each side of the mid-dorsal line and two or three at the sides. Terminal segment: dorso-lateral comb consisting of 7–9 spines of varying lengths; lateral comb consisting of 5 or 6 very short spines; pre-anal fringe consisting of 18–22 long spines and several short ones; anus surrounded by prominent swellings; aster with a broad median part and rather short, sharp prongs, the dorsal and lateral pairs close together and separated from the ventral pair.

Hart (1895) and Hine (1906) describe the pupa.

Range.—Nebraska, Quebec, Mexico, Texas, Florida.

This species is collected throughout the State and according to Leonard, (1926), it is abundant, but it can hardly be called so in this region. The writer saw two in the three summers of work, both on cows. They are vicious blood-suckers of cattle and horses, but are never abundant enough to constitute a serious pest. Ithaca—June 28th to August 21st.

The eggs are placed on grasses, sedges and other plants in marshy ground or along streams. The mass is large, very convex, and composed of several layers. When first laid, it is pure white and later turns brownish.

An egg mass was collected by the writer on July 13th on a *Typha* leaf at the margin of a slow-running stream. The mass was made up of five layers of eggs, the whole mass coming to a point somewhat above the center. It measured 12 mm. long, 6 mm. wide, and 6 mm. high, and was slightly wider than the leaf at the point of attachment. The eggs pointed up the stem at an angle of 45°.

The eggs hatched on July 18th, at least 250 larvæ emerging. Those were put in vials with sand and algæ. They molted immediately after emerging and a number of cast skins were found. They were fed on insect larvæ, earth worms and meat, mosquito larvæ proving very satisfactory for the young larvæ. As several were put in each vial, many cases of cannibalism were observed. A great variation in rate of growth was observed. Ten days after hatching, some were twice the size of others. On October 26th, the remaining larvæ ranged in size from 14 to 28 mm. On June 29th, the one remaining larva pupated and a male emerged July 10th.

Two larvæ were collected in the field; one near the outlet of Big Lake, near Tully, N. Y. on June 12th, and the other, close to where the egg mass was found, on August 7th. The pupal stage is close to two weeks in length.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
July 13, 1926	E. (Hatched July 18)		June 29	July 10	♂
June 12, 1928	L.	July 23	July 24	Aug. 7	♂

Tabanus bicolor Macquart.

Mature Larva.—Length, (alive), 17–18 mm.; (preserved), 20–22 mm. Yellowish brown to nearly white in color; mandibles black, head reddish brown, pharyngeal capsule dark brown; annuli very pale and indistinct. Prothorax with a very slender, anterior pubescent annulus not widened

laterally, but with very narrow dorso-lateral and median ventral, posterior projections. Thoracic segments dorsally and ventrally non-striated, laterally striated. Abdominal segments uniformly quite strongly striated, the anal segment dorsally, especially so. Ventral and lateral prolegs short, rounded, with fine pale setæ; the dorsal pair flat and fused without setæ. Anal segment with a narrow posterior ring of dark brown pubescence, one or two pairs of very small, pale, dorso-lateral spots, anus surrounded by pale pubescence extending somewhat laterally of the anus. Siphon short, rounded, finely striated. Tracheal trunks large, white, darker in the anal segment and siphon; spiracular cleft yellowish brown. Graber's organ usually with 6–8 pairs of bodies.

Pupa.—Length, 15–16 mm. Frontal carinæ moderately prominent, the lateral pair scarcely separated from them. Anterior setiferous tubercles rather broad, projecting little above the surface of the head. Abdominal segments with the usual rows of spines. The area between the fringes of spines and the inter-segmental line posterior to it, very finely reticulated. Pre-anal fringe in female consisting of about five, short, stout spines on each side; in male about 20–24, long and slender in the middle, short and very stout laterally. No dorso-lateral or lateral combs. Aster broad, the lateral prongs heavy, the dorsal prongs widely separated and close to the base of the lateral prongs, smaller, and curving laterally at the tip; ventral pair very short.

Range.—Canada, Illinois, New York, Maryland.

This rather uncommon species is found throughout the southern part of the State from late June to late August. The writer failed to collect any adults during the course of this work. Hine, (1903), did not observe it annoying stock. Ithaca—June 30th to August 11th.

Four larvæ were collected. One was found in the muddy bank of a stream near Ithaca on June 17th, 1926. The other three were collected in mud at the margin of a small pond in an open pasture lot about twelve miles from Ithaca, on June 17th, 1928. The pupal period in the laboratory was about ten days.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
June 17, 1926	L	July 13		July 25	♀
" 17, 1928	L		July 16	" 26	♂

Tabanus minusculus Hine.

Mature Larva.—Length, (alive), 18 mm. Body translucent, bright green; annuli quite distinct; the narrow posterior ring of the prothorax not widened laterally. Prolegs short with fine setæ. Anal segment non-pubescent except for the anus and a narrow ring around it. Siphon short, finely striated. Spiracular cleft pale brown.

Female Pupa.—Length, 15 mm. Frontal setiferous tubercles nearly absent, the setæ coming directly from the surface of the head; the frontal carinæ scarcely visible, the front of the head rounded. Dorso-lateral comb of terminal segment consisting of about seven rather short spines; lateral and pre-anal combs close together, each consisting of six or seven short spines. Aster with dorsal and ventral prongs very small, the lateral prongs large.

Range.—Canada, Maine, Massachusetts, New York.

This species appears to be quite uncommon in the State. No adults were collected by the writer.

On May 24, 1928, Dr. Paul R. Needham gave the writer a larva which he had collected in sphagnum moss at the McLean Bogs. On June 27th, it had pupated, and on July 3rd, an adult female emerged. It was sent to Dr. Hine and determined by him.

Tabanus nivosus Osten-Sacken.

(Figure 11.)

Mature Larva.—Length, (living), 25–28 mm., (preserved), 30–34 mm. General color pale yellow; head capsule reddish brown, mandibles brownish black; annuli very indistinct, there being only very sparse pubescence in the vicinity of the prolegs. Ventral thoracic bristles black, usually double. Prothorax with a narrow, yellowish anterior ring, slightly widened laterally. Dorsal and ventral areas of all the segments except the anal, non-striated; lateral areas very finely striated except on the prothorax, where the striæ are quite coarse. Prolegs short, with fine yellowish setæ. Anal segment coarsely striated on the wide, anterior part, quite finely on the narrower posterior part, there being an increase in the number of striæ here and not solely a convergence of those on the anterior part. Anus finely pubescent, the anterior and posterior crescentic protuberances surrounding it covered with coarse, brownish black setæ; laterally, just above the anus, a patch of rather coarse, yellowish brown pubescence. Siphon of moderate size, finely striated, and often provided with a few yellowish hairs at the tip.

Pupa.—Length, 19–21 mm. Frontal tubercles moderately prominent, rugose, slightly oblique. Dorso-lateral and lateral combs of the terminal segment present, the former with longer and slenderer spines than the latter; pre-anal fringe in female consisting of 8–10 slender spines on each side; in male of 25–30 all together. Aster with long lateral prongs, the dorsal and ventral pairs short.

The larva and pupa of this species has previously been described in detail by Cameron (1926).

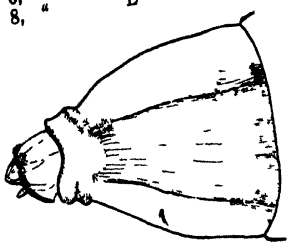
Range.—Saskatchewan, New York, Ohio, New Jersey.

This species is moderately abundant in the State in June and July. The writer collected one adult, the only one recorded

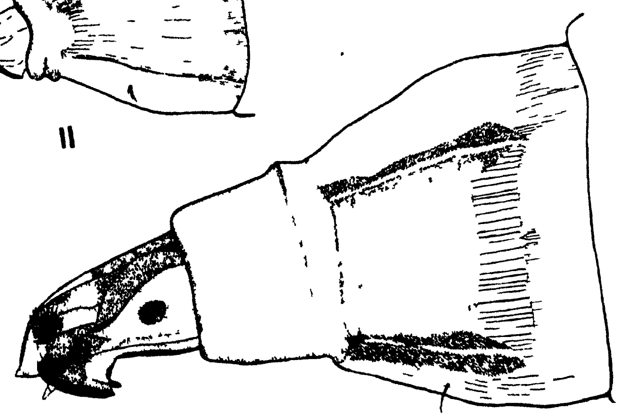
from Ithaca, on June 29th. Hine (1903a) in Ohio, and Cameron (1926) in Saskatchewan, found it attacking man and horses readily, the former finding it an annoying pest at the bathing beach.

Seven larvæ were collected in the muddy banks of small streams. The pupal period was about 15 days, in the laboratory. The following table gives the data on those reared.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 13, 1928	L		June 3	June 19	♂
Sept. 6, 1927	L		" 1	" 15	♀
" 6, "	L		" 16	" 30	♀
" 8, "	L		" 12	" 28	♂



11



12

Fig 11. *Tabanus nivosus* O.-S Lateral view of head and prothorax of larva. Magnified 13.5 diameters

Fig 12. *Tabanus reinwardtii* Wied Lateral view of head and prothorax of larva Magnified 24 diameters.

Tabanus reinwardtii Wiedemann

(Figure 12.)

Mature Larva.—Length, (alive), 27–30 mm, (preserved), 36–40 mm. Width, 4 mm. General color white; head capsule reddish brown, the mandibles black; the dorso-lateral hair tufts reddish; annuli usually grayish brown, sometimes yellowish. Dorsal and ventral areas of prothorax with almost no striæ; lateral areas finely striated. Prothorax

with a narrow anterior pubescent ring with a pair of dorso-lateral and a pair of ventro-lateral posterior projections; the area between these pubescent; a mid-ventral line as long as the others, none of them reaching the posterior margin of the segment; meso- and metathorax with a narrow anterior ring, wider laterally with a dorso-lateral, two lateral, and a ventro-lateral, slender, posterior projection on each side. Ventral thoracic bristles brownish. Abdominal segments 1–7 with annuli growing broader posteriorly, with a dorsal, transverse, non-pubescent area; these segments also with a posterior ring, widest on the seventh segment; abdomen with lateral areas more finely striated than the dorsal or ventral; prolegs quite short, tipped with fine yellowish or brownish setæ. Anal segment with a series of four dorso-lateral spots often more or less fused; when separate, they consist of an anterior, rather median pair, a slightly more lateral and posterior pair, and two more, one behind the other, posterior to these; usually the latter three pairs are fused on each side giving an L-shaped mark with the short arm anterior and pointing laterally; from the rather narrow, but definite posterior ring a pair of pubescent lines run forward and then down, on each side, to join the pubescence of the posterior anal protuberance; anterior anal protuberance also distinctly pubescent. Anus quite prominent. Siphon about the length of the posterior ring, conical, finely striated, with a prominent, vertical spiracular slit. Graber's organ usually showing one or two pairs of bodies in the sac and one to three bodies, in tandem, in the tube.

Pupa.—Length, 23–25 mm. Yellowish or reddish brown in color. Median frontal carinæ prominent, separated by a narrow cleft; lateral carinæ smaller, closely joined to the median pair; area around carinæ very rugose; frontal setiferous tubercles prominent. Abdominal spiracles quite prominent. Dorso-lateral comb of the terminal segment consisting of four or five spines; region of lateral comb indicated by a rugose swelling; pre-anal fringe in female consisting of four or five spines on each side. Aster broad, the prongs of moderate size, sharply pointed and slightly recurved at the tips; the dorsal pair extends nearly straight up and is about equal in size to the lateral pair; in the female, the ventral prongs are somewhat smaller than the others; in the male, the three pairs are nearly equal in size.

The larva and pupa of this species has been previously described in detail by Cameron, (1926).

Range.—Canada, Colorado, New York, Illinois, Maryland.

This species is rather infrequently encountered throughout the State during the mid-summer. Although this was the most frequently collected *Tabanus* in the larval state, only one adult, and that a battered male, was collected during the course of this study. Cameron (1926) and Philip (1928) also found this disparity between the number of larvæ and adults encountered. Cameron never found it attacking horses or cattle. Ithaca—June 25th–August 6th.

Cameron (1926) describes an egg mass laid by a reared female.

Eighty or more half grown to fully grown larvæ were collected in every month from April to December with the exception of October. Over half of these were collected in July. They were found in rather heavy mud close to the waters edge of a sluggish backwater fed by springs, of a rapid stream, and in a cat-tail bog. One was collected at the edge of a stream in a dense mass of willow rootlets. The larvæ ate earthworms with great avidity and often attacked the worm the instant it was put in the jelly glass. Several times I have seen a larva seize a worm, hang on in spite of its struggles, and in a very short time cut the worm in two.

Pupation occurred in the laboratory from May 24th to July 15th. The pupal period was about 17 days. The following table gives the life history data of those successfully reared.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
April 14, 1927	L			May 2.	♂
May 12, "	L		June 14	July 1	♀
" 12, "	L	June 14	" 16	" 1	♂
June 18, "	L		" 26	" 1	♀
Nov. 24, 1926	L	May 19	May 22	June 11	♂
" 24, "	L			" 1	♂
Dec. 1, "	L	May 30	June 1	June 17	♀

Tabanus trepidus McDunnough.

Mature Larva.—Length, (living), 22–26 mm. General color bright, translucent green; annuli brownish; head brownish, the pharyngeal capsule black. Prothorax with a narrow anterior ring not widened laterally; finely striated laterally and ventrally; meso- and metathorax with a pubescent anterior ring and slender posterior projections at the dorso-lateral line. Abdomen finely striated throughout; anal segment with a narrow, dark posterior ring and a narrow ring of pubescence around the anus; otherwise non-pubescent. Siphon short, rounded, finely striated. Tracheal trunks brown through anal segment and siphon. Spiracular cleft dark brown.

Pupa.—Length, 19–21 mm. Frontal carinæ absent, the area between the antennæ gently rounded with just a trace of a median groove. Frontal setiferous tubercles absent, the setæ coming directly from the surface of the head; antennæ very flat, broad at the base, forming an equilateral triangle. Dorso-lateral comb of terminal segment of 4–5 spines in the male, 2–3 in the female; lateral comb present in both sexes with 5–10 spines, usually more in the male; pre-anal fringe in male consisting of a row of long spines running from one lateral comb to the other. In the female, 7–10 on each side; aster with sharply

pointed prongs, slightly recurved at the tip; dorsal pair short, pointing straight up; lateral pair very large, pointing up and back; ventral pair very short, pointing slightly up.

Range.—British Columbia, Ontario, Nova Scotia, New York.

This species is infrequently encountered in the cooler portions of the State in mid-summer. No adults were collected by the writer nor have any been recorded from Ithaca.

Five larvæ were collected in sphagnum moss in a small upland bog. They were extremely active and viciously attacked the writer, puncturing the skin and causing a sharp, stinging pain. They readily fed on earthworms.

Pupation occurred in early July, the pupal period lasting 12 to 13 days. The following table gives the data on the four successfully reared. The fifth pupated but failed to emerge. The specimens were determined by Dr. Hine.

Collected	*Stage*	*Prepupa*	*Pupa*	*Adult*	*Sex*
May 21, 1927	L		June 9	June 21	♂
" 21, "	L		" 9	" 21	♂
" 21, "	L	June 9	" 10	" 23	♀
" 21, "	L			July 6	♀

Conclusions.

A great deal remains to be learned in regard to the bionomics of the Tabanidæ. Relatively few species have been studied with any degree of thoroughness and it is particularly important that the early stages should be sought elsewhere than in the vicinity of water. The way in which the larvæ pass the winter, their food, their length of life and the number of molts all require further study.

The larvæ present a number of characters of value for determination of the species, and as new larvæ are described, the preceding imperfect key can be enlarged and improved.

Finally, the writer wishes to acknowledge his particular indebtedness to Dr. Robert Matheson who suggested this problem and under whose kind and able direction it was carried out. To Dr. James S. Hine many thanks are due for the identification of several species and for many helpful suggestions. Also, the writer is grateful to Mr. Albert W. Force for the two drawings of posterior spiracles (Figures 3 and 4). To the many others who have shown an interest in the work and who have donated specimens, the author expresses his sincere gratitude.

BIBLIOGRAPHY.

Brimley, C. S. 1911. Notes on the life-histories of Tabanidae (Diptera). Ent. News 22: 133.

Cameron, A. E. 1926. Bionomics of the Tabanidae (Diptera) of the Canadian Prairie. Bull. Ent. Res. 17: 1–42.

Davis, J. J. 1919. Contributions to a knowledge of the natural enemies of Phyllophaga. Illinois Nat. Hist. Survey Bull. 13: 53–138.

Garman, H. 1910. An outbreak of gadflies in Kentucky. Kentucky Agr. Expt. Sta. Bull. 151.

Hart, C. A. 1895. On the Entomology of the Illinois River and adjacent waters. Illinois State Lab. Nat. Hist. Bull. 4: 149–273.

Herms, W. B. 1915. Tabanids breeding in rice-fields. Pan-Pacific Ent. 4: 91–92.

Hine, J. S. 1901. Collecting Tabanidae. Ohio Nat. 2: 167.

1903a. Tabanidae of Ohio. Ohio State Acad. Sci. Spec. Paper No. 5.

1903b. On the life history of Tabanus vivax. Ohio Nat. 4: 1–2.

1906. Habits and life histories of some flies of the family Tabanidae. U. S. D. A., Bur. Ent., Tech. Bull. 12: 19–38.

Isaac, P. V. 1924. Papers on Indian Tabanidae I–III. Mem. Dept. Agric. Ind., Ent. Ser. 8: 53–62.

1925a. Papers on Indian Tabanidae IV–VII. Mem. Dept. Agric. Ind., Ent. Ser. 8: 93–109.

1925b. Papers on Indian Tabanidae VIII. Mem. Dept. Agric. Ind., Ent. Ser. 9: 21–28.

Jones, T. H. and Bradley, W. G. 1923. Observations on Tabanidae (horseflies) in Louisiana. Jl. Ec. Ent. 16: 307–312.

1924. Further observations on Tabanidae (horseflies) in Louisiana. Jl. Ec. Ent. 17: 45–50.

King, H. H. 1908. Report on Economic Entomology. Rept. Wellcome Research Lab., Gordon Memorial College, 3: 201–248.

1910. Some observations on the bionomics of Tabanus par and T. taeniola. Bull. Ent. Res. 1: 99–104.

1911a. Some observations on the bionomics of Tabanus ditaeniatus Macquart and T. kingi Austen. Bull. Ent. Res. 1: 265–274.

1911b. Report on Economic Entomology. Rept. Wellcome Research Lab., Gordon Memorial College, 4: 95–150.

1914. Further notes on the bionomics of Tabanus ditaeniatus Macq. and T. taeniola P. de B. Bull. Ent. Res. 5: 247–248.

1921. Tabanidae. **In** The Practice of Medicine in the Tropics by W. Byam and R. G. Archibald. Vol. 1: 410–419.

1926. A note on the bionomics of Tabanus fasciatus niloticus Aust. Bull. Ent. Res. 16: 359.

Krober, O. 1926. Die Chrysops-Arten Nordamerikas einschl. Mexicos. Stett. Ent. Zeit. 87: 209–353.

Lecaillon, A. 1906. Sur quelques points de l'histoire naturelle des tabanides, en particulier de Tabanus quatuornotatus Meig. Compt. rend. Soc. Biol. 60: 459.

1907. Sur la ponte des oeufs et la vie larvaire des tabanides, particulairement des Taon a quatre taches. Ann. Soc. Ent. France 74: 20–28.

1911. Nouvelle observations sur la ponte des oeufs et la vie larvaire du Tabanus quatuornotatus Meig. Ann. Soc. Ent. France 80: 487.

Leonard, M. D. 1928. List of the Insects of New York. Cornell Univ. Agr. Exp. Sta. Memoir 101.

Malloch, J. R. 1917. A preliminary classification of Diptera, exclusive of Pupipara, based upon larval and pupal characters, with keys to imagines in certain families. Bull. Illinois State Lab. Nat. Hist. 12: 161–407.

Marchand, W. 1917a. Notes on the early stages of Chrysops (Diptera, Tabanidae). Jl. N. Y. Ent. Soc. 25: 149–163.

1917b. An improved method of rearing tabanid larvae. Jl. Ec. Ent. 10: 469–472.

1919. Collecting the larvae of Tabanus and Chrysops (Dipt.) Ent. News 30: 131–137.

1920. The early stages of Tabanidae (Horse-flies). Rockefeller Institute for Medical Research Monograph No. 13.

McAtee, W. L. 1911. Facts in the life history of Goniops chrysocoma. Proc. Ent. Soc. Washington, 13: 21–29.

Mitzmain, M. B. 1913. The biology of Tabanus striatus Fabr., the horsefly of the Philippines. Philippine Jl. Sci., Sect. B. 8: 197–218.

Mosier, C. A. and Snyder, T. E. 1918a. Notes on gadflies in the Florida Everglades. Proc. Ent. Soc. Washington, 20: 115–126.

1918b. Further notes on Tabanidae in the Florida Everglades. Proc. Ent. Soc. Washington, 20: 182–184.

1919. Notes on the seasonal activity of Tabanidae in the lower Everglades of Florida. Proc. Ent. Soc. Washington, 21: 186–196.

Neave, S. A. 1915. The Tabanidae of Southern Nyasaland with notes on their life histories. Bull. Ent. Res. 5: 287–320.

Osburn, R. C. 1913. Tabanidae as inhabitants of the hydrophytic area. Jl. N. Y. Ent. Soc. 21: 63–65.

Osten-Sacken, C. R. 1875–6. Prodrome of a monograph of the Tabanidae of the United States. Mem. Boston Soc. Nat. Hist. 365–397, 421–479, and 555–560.

Parman, D. C. 1928. Experimental dissemination of the Tabanid parasite Phanurus emersoni Girault, and biological notes on the species. U. S. D. A. Circ. 18.

Philip, C. B. 1928. Methods of collecting and rearing the immature stages of Tabanidae (Diptera). Jl. of Parasitology 14: 243–253.

Snyder, T. E. 1916. Notes on horseflies as a pest in Southern Florida. Proc. Ent. Soc. Washington 18: 208–211.

1917. A peculiar habit of a horsefly (T. americanus) in the Florida Everglades. Proc. Ent. Soc. Washington 19: 141–145.

Stammer, H. J. 1924. Die larven der Tabaniden. Zeitschr. Wiss. Biol. Abt. A. Zeitschr. Morphol. Okol. Tiere 1: 121–170.

Surcouf, J. M. R. 1921. Diptera: Family Tabanidae. Genera Insectorum Fasc. 175.

1922. Note sur un Diptere a vie larvaire littorale, Tabanus (Ochrops) seurati n. sp. Bull. Soc. Ent. France 19: 297–299.

1923. Note sur la biologie des larves de quelques Dipteres piquers. Bull. Soc. Ent. France 20: 131–132.

Surcouf, J. M. R. and Fischer, E. 1924. Note sur la vie larvaire et nymphale du Tabanus bromius L. Bull. Soc. Ent. France 21:232–237.

Walton, W. R. 1908. Notes on the egg and larva of Goniops chrysocoma (O.-S.) Ent. News 19: 464–465.

Webb, J. L. and Wells, R. W. 1924. Horseflies: Biologies and relation to western agriculture. U. S. D. A., Bull. 1218: 1–36.

THE GENITALIA AND WING VENATION OF THE CUCUJIDÆ AND RELATED FAMILIES*

J W Wilson.

CONTENTS

INTRODUCTION.

The family Cucujidæ has attracted considerable interest because of the remarkable structural differences found in some of the genera This diversity of structure indicates that the family is a very old one which has lost many of the intermediate forms. Sharp and Muir ('12) found that the male genitalia of the Cucujidæ are also very variable and for this reason they give the family a central position in the series Cucujoidea. A number of families are then derived from the Cucujidæ, including the Coccinellidæ and Endomychidæ. In some cases the connecting links between the families are rather obscure. A study of the morphology of the Coccinellidæ begun at North Carolina State College convinced me that a further study of the genitalia of the Cucujidæ and the related families would probably clarify the relationship of these families.

The venation of the wings of the Coleoptera was used successfully by Lameere (1900) and Ganglbauer (1903) in determining the phylogenetic position of the larger groups of the Coleoptera, but I have been unable to find any reference to a detailed study of the wings of the Cucujoidea. I have included a description of the wings of these families in order to compare the results from the study of the two organs.

*Contribution from the Entomological Laboratory, Bussey Institution, Harvard University, No. 318.

SECTION I

Comparative Study of the Genitalia of the Cucujidæ and Related Families.

REVIEW OF PREVIOUS WORK.

The first work on the subject of the genitalia of the Coleoptera was carried on by Verhoeff (1893) who studied the terminal abdominal segments, as well as the male and female genitalia of seventeen families. After a very detailed discussion of these parts Verhoeff concludes that the Coccinellidæ are sufficiently distinct from the other Coleoptera to justify separating them as a suborder, Siphonophora, from the remainder of the Coleoptera which are included in the suborder, Asiphona. This view was very strongly attacked by Weise (1895) and Schwartz (1895). Verhoeff's conclusions have received little attention in Europe, but Leng (1920) in his introduction to the "Catalogue of the Coleoptera of North America" states that he gives the Coccinellidæ an isolated position with the hope that Verhoeff is partly correct.

The first general survey of the male genital tube in the Coleoptera was published in 1912 by Sharp and Muir. These authors divided the Coleoptera into the eight series Byrrhoidea, Caraboidea, Cucujoidea, Staphylinoidea, Malacodermoidea, Tenebrionoidea, Scarabaeoidea, and Phytophagoidea. The more primitive type of aedeagus is found in the series Byrrhoidea, while two types of genitalia are found in the family Colydiidæ. One type is characteristic of the Byrrhoidea, and the second characteristic of the Cucujoidea. The Cucujoidea is admittedly a series of heterogeneous nature subject to division. It is noteworthy that many of the families of the old series Heteromera are placed in the Cucujoidea, leaving the Cistelidæ, Lagriidæ, Monommidæ and Tenebrionidæ as a homogeneous series called Tenebrionoidea. The series Caraboidea (Adephaga of other authors) is recognized as the most distinct and homogeneous series of the Coleoptera. The Cupedidæ are shown to be distinct from the Caraboidea, and are placed in the series Byrrhoidea. The six series Caraboidea, Staphylinoidea, Malacodermoidea, Tenebrionoidea, Scarabaeoidea, and Phytaphagoidea each have characters in common but each also shows a definite direction of progressive modification.

Tanner (1927) made a study of the female genital tube and arranged the families much as Leng has arranged them in his catalogue of the Coleoptera.

In preparing the material for this paper I made an effort to obtain female as well as male specimens. After comparing the structure of

the females, however, I decided not to include them for the structure of the female tube differs very little among the genera of the Cucujidæ, or between the Cucujidæ and such families as Mycetophagidæ and Erotylidæ. The fact that the Endomychidæ and Coccinellidæ both showed a great shortening of the membranous ninth segment should be noted however.

Since frequent reference is subsequently made to Boving's division of the Cucujidæ on larval structures I thought it advisable to include a résumé of his results here.

Böving's (1921) studies resulted in a division of the Cucujidæ into four families. The family Silvanidæ includes the following genera: Telephanus, Nausibius, Coccidotropus, Eunausibius, Oryzaephispus, Cathartus and Silvanus, which are distinguished from the Cucujidæ by "absence of cerci. The eighth abdominal segment is normally developed; ninth, small, ventrally rudimentary; tenth, long, extending far behind the ninth segment; six ocelli." The family Cucujidæ possesses cerci, and is divided into two subfamilies Hyliotinæ and Cucujinæ. The Hyliotinæ includes the genera Brontes and Dendrophagus, while Psammoecus, Pediacius, Platisus and Cucujus constitute the subfamily Cucujinæ. A third family Laemophloeidæ is distinguished by "Maxillary mala (possibly galea) obtuse, with or without well defined uncus, which when present is laterally placed on inside of mala." The genera Prostomis and Dryocora (an Australian genus) are placed together in the subfamily Prostominæ. And Prostominia, Narthecius, Lathropus, Laemophloeus, Dysmerus, Hemipeplus, and Inopeplus form a second subfamily Laemophloeinæ. The genera Catogenus and Scalidia differ from the other genera to such an extent that Böving gives them the family name Scalidiidæ and places them with the larvæ of the Cleroidea series.

GENERAL MORPHOLOGY OF THE AEDEAGUS.

When the abdomen of a generalized Coleopteron is examined, nine or ten tergites and nine sternites may be easily distinguished. There are ten distinct tergites in *Hippodamia convergens* and *Enarsus bakewelli*. In the case of the latter species Sharp and Muir found ten sternites present. The anus opens on a small membrane between the tenth tergite and sternite so that the digestive tract is completely separated from the genital tube in *Enarsus bakewelli*. In the case of *Hippodamia convergens* and other members of the order the tenth sternite is reduced to such an extent that the anus is separated from the genital tube by a very short membrane which is continuous with the second connecting membrane (Fig. 52 CM2), connecting the aedeagus with the abdomen. The ninth sternite is a short segment bearing a spicule at the

anterior border. The attachment and shape of this spicule varies a great deal in different families. Sometimes it appears to be a direct continuation of the ninth sternite, and in these cases it is usually a long slender chitinous process. In other cases it is located in the membrane between the ninth sternite and the second connecting membrane.

In discussions of the abdomen and genitalia of the insects both morphologists and systematists have arrived at varying conclusions concerning the number of abdominal segments. Systematists usually limit themselves to numbering the segments which are clearly visible. Disagreement on this point has arisen among the morphologists for various reasons, which are summarized by Newell (1918) as follows: "(1) Because of the loss of certain sclerites. (2) Because of differences in the point of view: viz. some investigators begin to count at the cephalic, while others begin at the caudal end of the abdomen, and still others do not correlate closely dorsal and ventral sclerites. (3) Because, undoubtedly, of failure to observe the sclerites present in the caudal region, due in many cases to the lack of potash or other suitable reagents and methods for exposing chitinized parts."

In the coleoptera the first two sternites have usually fused completely with the third sternite, but in many cases vestiges of the first two sternites may be observed at the anterior border of the third sternite, and folded under the posterior coxæ. One or two caudal segments are also usually withdrawn into the abdomen. Thus it is seen that the number of segments given for the Coleoptera by various investigators varies from eight to eleven. Peytoureau (1895) finds eight in Hydrophilus and nine in Dytiscus, Kolbe (1893) counts nine in the Lamellicornia, Verhoeff (1893-96) numbers ten in the families he studied, while Berlese (1903) concludes that eleven abdominal segments is the typical number for the Coleoptera in general. Muir (1915) states that nine segments are usually present though he found ten complete segments in *Enarsus bakewelli.* Newell (1918) emphatically states that eleven segments are present in Harpalus, and Cybister females with ten segments in the males of these two genera and in both sexes of Hydrophilus and Doryphoria. *Doryphoria decemlineata* lacks the tenth sternite, however. In the Coccinellidæ and *Endomychus biguttatus* I have been able to count only ten tergites and nine sternites while in the Mycetophagidæ, Cucujidæ, Nitidulidæ, Monotomidæ, Phalacridæ, Erotylidæ, and Cryptophagidæ nine complete segments are present.

Eight tergites and six sternites are visible in the Coccinellidæ and Endomychidæ, the sixth visible sternite being in reality the eighth

sternite. The membrane connecting the ninth segment with the eighth is long, allowing the ninth and tenth segments to be withdrawn into the abdomen. As is illustrated in figures 37 to 53 tergite ten is closely attached to the irregularly shaped ninth tergite. The digestive tube opens at the posterior border of the tergite and is attached below to the second connecting membrane of the genital tube. The tenth sternite is absent and the second connecting membrane attaches to the posterior border of the ninth sternite.

In the remainder of the families studied, the eighth sternite is withdrawn into the abdomen and in the case of the Cucujidæ and Nitidulidæ the eighth tergite is also concealed under the seventh tergite. The digestive tract then opens at the posterior border of the ninth tergite and the genital tube at the posterior border of the ninth sternite.

The genitalia of insects are borne at the caudal end of the abdomen and the parts of the genitalia have been termed gonapophyses by Huxley. It would seem natural to homologize these appendages with the anlagen of the legs found on the terminal somites of the embryonic germ band, but there are two opposing views on this subject.

The following investigators have considered the genitalia or gonapophyses as developing from the abdominal anlagen of the legs: Weismann in 1866; Krapelin in 1872; Kowalewsky in 1872; Dewitz in 1875; Huxley in 1877; Chlodkowsky in 1891; and Wheeler in 1893. These authors differ, however, in the details of their explanation.

Wheeler (1893) traced these anlagen to the time of hatching in Xiphidium and pointed out that Dewitz in 1875 had traced the development of the ovipositor in *Locusts viridissima* to the adult so that we have a complete history of the anlagen to the adult. Wheeler concluded that part of his discussion as follows: "While there can be no doubt about the appendages of the eighth and ninth segments which go to form the two outer sheaths of the ovipositor or sting the development of the innermost pair of blades is by no means so satisfactory. But whether this pair is only a portion of the ninth pair of appendages, as most authors claim, or represents the tenth pair of appendages, as I maintain, the main question at issue is in no wise affected; for it still remains true that the ovipositor consists of two or three pairs of modified ambulatory limbs." In the male Xiphidium Wheeler has shown that the appendages on the ninth segment persist to form the definitive style, while the appendages of the eighth and tenth segments disappear very early. Cholodkowsky (1891) had previously made similar observations on Blatta. The style, therefore, must be considered homologous of the second pair of appendages.

On the other hand, a number of authors are of the opinion that the gonapophyses are not homologous with the ambulatory appendages. Heymons is one of the stronger opponents of the view held by Wheeler and others. After a study of a large number of species of Locustidæ, Gryllidæ, and Hemiptera, Heymons published a résumé of his work in 1899 in which he concludes that it is a fundamental principle in insect embryology that there is no relationship between the anlagen of the ambulatory appendages and the gonapophyses.

Heymons maintains that the genitalia in Xiphidium and other Locustidæ begin developing at a very early period, even before the atrophy of the anlagen of the segmental appendages. Heymons also claims that the very small size of the sternites in Locustidæ would lead to a confusion of the embryonic limb-rudiments with the developing gonapophyses. While in other forms where the sternites are larger, such as *Lepisma saccharina* and certain Hemiptera, Heymons asserts that the gonapophyses do not develop in the same region of the sternites where the anlagen of segmental appendages occur.

In spite of Heymons' objections the majority of embryologists and morphologists believe the genitalia to be derived from the anlagen of the segmental appendages. In the Hymenoptera, Lepidoptera, and Diptera the anlagen on the eighth, ninth and tenth segments disappear, as well as those on the anterior segments. This has led some authors to suppose that the anlagen remain undeveloped until some later stage in development. This view is expressed by Korschelt and Heider (1892) as follows: "We should have to suppose, as Graber also has pointed out, an embryonic rudiment remaining for a considerable time in a dormant condition. On the whole, the embryonal data seem to support the view of Balfour which Cholodkowsky adopted, and to which Graber was inclined, that the abdominal appendages of Lepidoptera and Hymenoptera are to be regarded as true limbs. We have already had several examples, in the Crustacea, of the disappearance and redevelopment of a limb and of a rudiment which has meanwhile been latent. A similar example is afforded among the insects by the thorasic limbs of many Hymenoptera. These appear as rudiments in the embyro, disappear later, and reappear in the imago."

In some Coleoptera no traces of the anlagen of the abdominal appendages is found in the developing embryo. In describing the ontogeny of Doryphora Wheeler (1889) makes the following statement in regard to the abdominal anlagen of the legs: "In none of the preceding stages have I observed what is so prominent in Blatta, viz. the appearance of appendages on the abdominal somites. There are not the slightest traces of even the pair of appendages of the first abdominal somite, which in Blatta develop into the large glandular organs of which I have treated elsewhere."

Verhoeff (1893-95) in his work on the genitalia of the Coleoptera and Hemiptera homologizes the median genital appendages with the distal segments of the legs, and the lateral gonapophyses with the coxæ of these legs, therefore, regarding the origin of two pairs of genitalia from one pair of ambulatory appendages belonging to one somite, instead of from two pairs belonging to two successive somites, or in other words, from at least four isolated evaginations having no connection with the anlagen of the segmental appendages found in the embryo.

Newell (1918) studied the morphology of four species of coleoptera with representatives of the other orders of insects. In this paper the genitalia are also homologized with the abdominal appendages of somites eight, nine and ten. The appendages are labelled I, II, and III.

and are considered to be derived from somites eight, nine and ten respectively. The sclerite labelled sternite 10 by Newell is the spiculum according to Sharp and Muir. Muir in 1915 has shown that this structure is developed during the pupal stage at the base of the second connecting membrane, and therefore can not be the tenth sternite. Newell labels the tubular portion of the aedeagus (equal to the median lobe of Sharp and Muir) as appendage III in *Harpalus calignosus* and *Doryphora decemlineata* while in *Cybister fimbriolatus* the same part is labelled appendage II, and the outer lateral lobes are labelled III. It is not clear from the figures which part is considered appendage II or III in Hydrophilus. Appendages I and II are believed to be present in all four forms studied though appendage I is rudimentary in males of Doryphora and is completely absent in *Harpalus calignosus*. These conclusions are based entirely upon comparative morphology of the imago.

Sharp and Muir (1912) give a completely different explanation of the origin of the genitalia after their study of the comparative morphology of the organ. They believed the genitalia to be developed as an invagination and chitinization of the membrane between the ninth and tenth segments and that no part of the sternites entered into the composition of the aedeagus. This explanation was more in accord with the observations on the embryology of the Coleoptera because none of the anlagen of the abdominal segments develop. Later Muir (1915 and 1918) studied the ontogeny of three species and found that the genitalia develop as they supposed from the membrane between the ninth and tenth sternites.

The forms studied by Muir were *Rhabdomerus obscura*, *Coccinella repanda*, and *Carpophilus humeralis*. In the early stages of the male pupa of these species the testes are attached, each by a fine testicular thread, to a small mass of cells between the ninth and tenth sternites. This cellular mass forms an invagination which increases in size and grows into the body cavity. At the apex of this tube where the testicular threads are attached another invagination takes place to form the ejaculatory duct. The membranous tube then evaginates and this evaginated portion forms the eurazygos, while the proximal part of the membrane becomes the second connecting membrane attaching the aedeagus to the body. The first development of the eurazygos is the formation of the tegminal fold separating the median lobe from the tegmen. The tegmen becomes thickened and chitinized. From the anterior end of the tegmen the second connecting membrane is again invaginated to form the tegminal strut while from the posterior end the lateral lobes are formed as outgrowths from the tegminal fold. While this is taking place a construction is formed about the eurazygos beyond the tegminal fold, dividing it into two parts. . The basal portion lengthens and becomes chitinized, forming the median lobe. The apical portion becomes crumpled and is later withdrawn into the median lobe as the internal sac. The median strut is developed as an outgrowth from the base of the median lobe and becomes heavily chitinized.

We may now discuss the general structure of the parts of the aedeagus of the forms studied.

In all cases except that of *Carpophilus pallipenis* the median lobe is well developed, more or less tubular, with a median orifice at the distal end and a median foramen at the proximal end. In many cases there is a median strut projecting from the proximal end of the median lobe to which muscles are attached. In the *Nitidulidæ* and related families the median lobe is articulated to the tegmen on the ventral aspect and swings in and out of the tegmen.

The tegmen in the generalized forms represented by the Mycetophagidæ consists of the basal piece and lateral lobes on the ventral aspect of the aedeagus. In such forms where there is no chitinous dorsal portion the second connecting membrane and the dorsal membrane of the tegmen are indistinguishable. But in a majority of the specimens the tegmen forms a complete ring around the median lobe The lateral lobes vary a great deal in position, being on the ventral aspect, at the sides, or on the dorsal aspect of the median lobe.

The internal sac is comparatively simple in all of the specimens studied. In the simplest form it is a straight tube and can hardly be distinguished from the ejaculatory duct. In *Glistrochilus fasciatus* the internal sac is highly specialized, having the proximal end formed like a bulb, bearing chitinized side pieces and setæ. A short curved flagellum is attached at the apex.

The flagellum is an inconstant structure, present in some genera and absent in others.

METHOD.

All of the material used in the preparation of the genitalia were dried museum specimens, some of it being very old. In order to remove the aedeagus the specimens were placed in water and heated for ten or fifteen minutes. The elytra were then spread apart and the tegmen carefully separated from the sternum with a fine needle. In most cases it was only necessary to separate the last two or three tergites from the sternites. The genitalia and dried contents of the abdomen were then removed, and placed in a solution of caustic potash. After the muscles had been dissolved away the genitalia were mounted in balsam between small cover glasses. A hole was punched in a rectangular piece of cardboard about .5 mm. thick, and the bottom cover glass glued in place. The depression thus formed was filled with balsam, and the aedeagus arranged in the desired position. The upper cover glass was then put in place, and a label placed on the opposite end of the cardboard. After drying, a pin was run through the cardboard and the mount was ready for study. This method has the advantage of making the genitalia readily available, and it obviates the danger of loss, which is considerable when very small specimens are being studied. If it becomes necessary to change the position of the aedeagus it was easily remounted by soaking the cover glasses off in xylol.

All of the drawings were made with the camera lucida. In the case of the genitalia the line placed at the side of the drawing represents one-fourth of a millimeter, except in *Glistrochilus obtusus* and *Languria bicolor* where the line is drawn to represent one millimeter.

SPECIAL ANATOMY.

MYCETOPHAGIDÆ.

Mycetophagus flexuosus Say. Fig. 25.

Median lobe (ML), tubular with a large oval median foramen (MF) at the proximal end, produced at each side of the median foramen to form two short strut-like projections which do not extend beyond the anterior border of the basal piece (BP). Median orifice (MO) a small circular opening at the extreme end of the median lobe. Internal sac (IS) a simple, tubular structure without flagellum or other modifications sometimes found in more highly evolved aedeagi. Tegmen composed of two parts, basal piece (BP) and lateral lobes (LL). Basal piece broad, extending beyond the median lobe for a short distance, transverse, rather broad, turned up at the sides so as to form a trough in which the median lobe rests. Lateral lobes attached to the basal piece by a thin membrane which allows movement of the lateral lobes. Thus we have the name trilobe applied to this type of aedoeagus. Lateral lobes (LL) enlarged and extending around the median lobe but not fusing on the dorsal surface to form a tube.

Typhoea fumata (L.). Fig. 23.

Median lobe (ML) as in *Mycetophagus flexuosus*, with the median foramen (MF) more elongate, median orifice (MO) at the extreme distal end of the median lobe. Basal piece (BP) broad and extending further around the median lobe than in the aedoeagus described above. Internal sac (IS) simple. Lateral lobes (LL) joined to the Basal piece as in *Mycetophagus flexus*. Lateral lobes almost contiguous on the dorsal surface.

The type of aedoeagus found in the Mycetophagidæ was designated as the trilobe type because of the intimate connection of the median lobe with the tegmen to form one component and the lateral lobe at each side of the median lobe forming the other two components of the trilobe aedoeagus.

CUCUJIDÆ

The genera usually placed together in this family show a very great diversity of structure in body characters. Such differences in external structure have caused some systematists to suggest that the family be divided. Böving (1921) recently published a plan for separating the group according to larval characters in which he recognizes four families. All of the genera available for dissection were studied in order to determine whether or not this division of the family would be substantiated or refuted by the evidence from the male aedoeagus. Fifteen of the twenty-two genera were dissected and figured.

It has already been pointed out in the case of the Mycetophagidæ that the tegmen is placed on the ventral aspect of the median lobe. This condition is also found in the Cucujidæ for the lateral lobes rest upon the sternites, and are not upon the dorsal aspect of the median lobe as described by Sharp and Muir. This then obviates the necessity of explaining how the lateral lobes of the tegmen came to lie on the dorsal aspect of the median lobe if we are to derive the Cucujid aedoeagus from the trilobe type of aedoeagus. That the Cucujidæ were probably derived from the trilobe type of aedoeagus is demonstrated by Hemipeplus and Dendrophagus.

Hemipeplus marginipennis (Lec.). Fig. 16.

Aedoeagus as long as the last two segments of the abdomen, very narrow and slender when compared with the aedoeagi of other genera. Median lobe (ML) a simple straight tube attached at the proximal end to the tegmen by a short connecting membrane. Median foramen at the extreme proximal end, large, oval in shape with the sides of the median lobe slightly produced. Median orifice (MO) a small rounded opening at the extreme distal end of the median lobe. Ejaculatory duct and internal sac undifferentiated. Internal sac small without flagellum. Tegmen consisting of broad rounded lateral lobes and a long Basal piece. The tegmen does not form a complete chitinous ring around the median lobe. Basal piece (BP) slender at the proximal end and extending slightly beyond the median lobe, becoming larger toward the middle and extending up around the median lobe; divided on the ventral side and continuing to slightly beyond the median lobe as two large lateral lobes, (LL).

This aedoeagus like that of the Mycetophagidæ is distinct from the other Cucujidæ in that the tegmen does not form a complete ring around the median lobe. The median lobe itself is a simple tubular structure in the Mycetophagidæ and in Hemipeplus. On the other hand the aedoeagus differs from the Mycetophagidæ in that the lateral lobes are completely fused with the basal piece so that they seem to be continuations of the basal piece.

Inopeplus reclusa (Lec.). Fig. 32.

The aedoeagus of this form is very small and slender, measuring .5 mm. in length. Median lobe (ML) tubular, and straight with the small rounded median foramen at the extreme proximal end, and the small median orifice (MO) at the opposite end. Internal sac (IS) a simple straight tube without flagellum. Tegmen on the ventral side of the aedoeagus, not forming a ring around the median lobe; separated into two lateral lobes which extend a little beyond the end of the median

lobe. The tegmen bears at about the middle of each side a short projection which extends toward the mid-ventral line.

Inopeplus immunda Reit. Figs. 26 and 27.

Median lobe (ML) short appearing as a straight tube from a dorsal view but when observed from a lateral view it is seen to be curved at the middle and slightly expanded dorsoventrally with the median foramen in the form of a narrow slit-like structure. Median orifice (MO) a small circular opening at the distal end of the median lobe. Internal sac simple, tegmen about the same length as the median lobe, forming a groove-like receptacle for the median lobe; divided beyond the middle into two projections or lateral lobes.

The aedoeagus of both *I. reclusa* and *I. immunda* have the tegmen located on the ventral side of the median lobe with the basal piece extending about two-thirds of the length of the median lobe, and divided into two lateral lobes beyond this point. The tegmen of *Hemipeplus marginipennis* is of similar structure, but the lateral lobes more nearly enclose the median lobe than in Inopeplus. The fact that the tegmen does not completely encircle the median lobe places Inopeplus with Hemipeplus near the Mycetophagidæ.

Prostomis mandibularis Fab. Fig. 28.

Aedoeagus very small, flattened dorso-ventrally, 0.5 mm. in length which is very short in comparison with the length of the adult body. Median lobe (ML) about one-half as long as the tegmen, tubular, with the larger median foramen at the proximal end and the smaller median orifice at the opposite end; attached to the tegmen by a very short connecting membrane. Internal sac (IS) simple, without flagellum. Tegmen located ventrad of the median lobe and consisting of two parts the basal piece (BP) and lateral lobes (LL). Basal piece convex from a ventral view, distinctly separated from the lateral lobes by a more heavily chitinized area which extends along the mid line. Lateral lobes short prolonged into slender seta-like processes.

Prostomis mandibularis like Inopeplus and Hemipeplus has an aedoeagus which is small with the tegmen not completely encircling the median lobe. Because of this general similarity Prostomis is placed near Hemipeplus and Inopeplus. But when we consider the details of the parts the aedoeagi are very different. In Prostomis, the basal piece is expanded and convex, the lateral lobes are produced into small seta-like projections, and the median lobe is only about one-half as long as the tegmen. In Hemipeplus and Inopeplus the basal piece is long and slender, the lateral lobes bear no setæ of any kind, and the median lobe is almost as long as the tegmen.

Dendrophagus cygnaei Mann. Fig. 11.

Aedoeagus flattened dorso-ventrally but rather long and broad. Median lobe (ML) not completely chitinized on the dorsal surface, tapering to a point on the ventral surface. Median orifice (MO) very large, elliptical in shape. Ventral surface of the median lobe produced into a long flattened median strut (MS) which extends a short distance beyond the basal piece. Internal sac (IS) simple, without flagellum. Tegmen ventrad of the median lobe and forming a complete ring around the median lobe. Basal piece (BP) long and broad, extending well up around the sides of the median lobe, with a short connecting piece across the dorsal surface. Lateral lobes broad and flattened, extending beyond the distal end of the median lobe, and bearing numerous setæ.

The tegmen of Dendrophagus is essentially similar to the tegmen of the trilobe type in Hemipeplus, both having the broad basal piece and the flattened lateral lobes on the ventral surface. The necessary changes required for the derivation of the Cucujid aedeagus from the trilobe type are a lengthening of the first connecting membrane between the median lobe and the tegmen, and a formation of a complete ring around the median lobe. The lengthening of the first connecting membrane does not take place in Dendrophagus. The ring around the median lobe is completed by a chitinization of the tegmen to form a short band across the dorsal surface.

Brontes dubius Fabr. Fig. 8.

Aedoeagus broad and flattened dorso-ventrally. Median lobe (ML) fusiform, with both distal and proximal ends pointed. Median foramen small, V-shaped and located on the dorsal surface. Median orifice a rather large opening on the ventral surface. Internal sac (IS) about three times as long as the median lobe, with four thickened areas on the walls of the portion inside the median lobe; expanded beyond the median foramen, and with small spines turned basad in localized areas. A long branched flagellum (F) at the proximal end. Surrounding the flagellum there are numerous setæ which are turned toward the median orifice. Tegmen consisting of a broad chitinous area on the dorsal surface; ventral surface membranous, with only a short chitinized band to which the broad lateral lobes are attached. Lateral lobes on the ventral side of the median lobe and extending well beyond the median lobe.

In this form the basal piece is very short while on the dorsal surface there is a broad flattened dorsal piece (DP). This is the exact opposite of the condition in Dendrophagus. The two genera Dendrophagus and Brontes are closely related when the body structures are studied, being placed next to

each other by all systematists. That such a radical change should occur between the two genera seems remarkable for the number of species in both genera is small. Then it appears that the intermediate forms have disappeared. In Brontes the lateral lobes are broad and definitely separated from the tegmen by sutures. In Dendrophagus the lateral lobes are flattened and not separated from the tegmen. The internal sac of Brontes has attained a very complicated condition, with a branched flagellum present while the internal sac of Dendrophagus is simple being unmodified in any respect.

Brontes planatus (L.). Fig. 9.

Aedoeagus short and flattened dorso-ventrally. Median lobe sharply pointed at the distal end, with a large oval median orifice on the ventral surface; produced at the proximal end into a median strut (MS) which tapers to a slender strut toward the distal end. Median foramen a large opening ventrad of the median strut. Internal sac slender, without thickened areas in the distal portion but with a long area near the middle which bears short tubercules; flagellum long and branched without setæ surrounding it as in *B. dubius*. Dorsal piece (DP) on the dorsal aspect of the aedeagus, broad, shallowly and broadly emarginate at the anterior margin. Lateral lobes attached to a very short chitinous band on the ventral aspect of the aedeagus; narrow and about two-thirds as long as the basal piece.

The aedoeagus of the two species of Brontes are very similar in general shape and structure. They differ however in many minor points. The median lobe in *B. planatus* is produced into a broad median strut which is lacking in *B. dubius*. The basal piece is emarginate in *B. planatus* while it is rounded at the anterior margin in *B. dubius*. The internal sac is less complicated and the lateral lobes are narrower and shorter in *B. planatus*.

Telephanus velox Hald. Fig. 3.

Aedoeagus long and narrow, very compressed dorso-ventrally. Median lobe (ML) short, tapering to a point at the distal end, with the median orifice (MO) on the dorsal surface of the median lobe. Ventral edge prolonged into a long, slender median strut which is broadly expanded at the distal end. Median foramen (MF) a large oval opening dorsad of the median strut. Internal sac (IS) very long and slender, without a flagellum. Tegmen consisting of a broad band on the dorsal surface connected to the ventral portion by long narrow chitinous bands. Lateral lobes (LL) attached to a wider band on the ventral aspect of the aedeagus; broad, flattened, and extending well beyond the median lobe.

In this form the dorsal portion of the tegmen is much smaller than in Brontes and is placed in a much more anterior position, being connected by long narrow bands to the basal piece (BP). The median strut (MS) is very long and expanded in Telephanus while in Brontes it is short. The internal sac of Telephanus is long and slender, without flagellum; and in Brontes the internal sac bears tubercules and setæ with a branched flagellum. In both genera the lateral lobes are broad, flattened and attached to a very short basal piece.

Oryzaephilus surinamensis (L.). Figs. 6 and 7.

Aedoeagus compressed dorso-ventrally. Median lobe (Fig. 7) rounded at the distal end, broadest at the middle, tapering from the middle to a point at the proximal end. The median strut (MS) rather broad, arising from the ventral surface of the median lobe; omitted in Fig. 7. Median foramen (MF) V-shaped. On the dorsal surface close to the median foramen there are two diverging rows of large stiff bristles which become shorter toward the distal end. Median orifice, a slit-like opening at the distal end between the flattened dorsal and ventral surfaces of the median lobe. Internal sac (IS) about twice as long as the median lobe, without flagellum. Tegmen consisting of a narrow band or basal piece, on the ventral aspect, to which the lateral lobes and the dorsal piece are attached. Lateral lobes long and broad, bearing long branched setæ at the distal end; not separated by a suture from the basal piece. Dorsal piece connected to the basal piece by narrow chitinous bands.

The aedoeagus of this and the preceding form resemble each other very closely in the shape of the dorsal piece, undifferentiated internal sac, and in the similarity of shape of the median strut.

Nausibius clavicornis (Kug). Fig. 4.

Aedoeagus long and compressed. Median lobe long and slender, with the distal end enlarged and rounded. The middle portion of the median lobe is narrow, bearing at each side a row of stout bristles. Between these rows of bristles there is a long, narrow, membranous area. Dorsal edge of the median lobe produced to form a short projection; ventral edge continued into a long median strut (MS) which is expanded at the distal end. Internal sac simple, without flagellum; about three times as long as the median lobe. Tegmen consisting of the short basal piece, lateral lobes and dorsal piece. Basal piece (BP) short and flattened, truncate at the anterior border; anterior border, emarginate between the lateral lobes. Lateral lobes shorter than in Oryzaephilus. Dorsal piece (DP) long and narrow, placed some distance from the basal piece to which it is connected by long, narrow, chitinous pieces.

The aedoeagus of this form like Oryzaephilus has two rows of stout bristles on the dorsal surface of the median lobe, though in different positions in the two genera. In Nausibius the bristles are at the sides of the median lobe while in Oryzaephilus the bristles are near the middle of the dorsal surface. As to the possible uses or function of these bristles I am unable to make any suggestions. The lateral lobes of Oryzaephilus are fused completely with the basal piece while in Nausibius the lateral lobes are separated from the basal piece as in Brontes or Telephanus. The median strut in Telephanus, Oryzaephilus and Nausibius is long slender and expanded at the distal end. The internal sac is also long and without a flagellum in these three forms.

Cathartus opaculus (Lec.). Figs. 1 and 2.

Aedoeagus small, very greatly compressed. Median lobe (ML) enlarged at the distal end; distal border thickened and forming a tooth-like projection at the middle. Median orifice a broad crescent-shaped opening on the ventral surface. Median lobe constricted, forming a median neck-like connecting area between the distal and proximal ends; proximal end expanded with the median foramen on the dorsal surface and a slender median strut (MS) continuous with the ventral edge. Internal sac simple, without flagellum. Dorsal piece of the tegmen broad and rather long. Side pieces, connecting with the basal piece, short. Basal piece, on the ventral aspect of the Aedoeagus, not as wide as the expanded part of the median lobe. Lateral lobes fused to the basal piece, very short and small with only two setæ at the end of each lateral lobe.

The aedoeagus of this form belongs to the Telephanus, Oryzaephilus, and Nausibius group because the lateral lobes and basal piece are on the ventral aspect of the median lobe, the median strut is on the ventral surface of the median lobe and the internal sac is long and simple.

Silvanus bidentatus Fab.

Aedoeagus small, resembling Cathartus very much. Median lobe broadly rounded and more heavily chitinized at the distal end with the median orifice on the ventral surface; not constricted at the middle as in Cathartus. Median foramen on the dorsal surface with the median strut projecting from the ventral margin. Median strut about the same length as in Cathartus. Internal sac simple without flagellum. Dorsal piece large, rectangular in shape, with short side pieces connecting it to the basal piece on the ventral surface. Basal piece very short consisting only of a band to which the narrow, curved lateral lobes are attached. Lateral lobes bearing two small setæ at the distal end.

The aedoeagus of Silvanus and Cathartus have a large dorsal piece, and a very short basal piece to which the lateral lobes are attached. These characters indicate that the two genera are also closely related to Brontes. But as has already been pointed out in connection with Cathartus both Silvanus and Cathartus may be included in the group with Telephanus. The aedoeagus of the five genera, Telephanus, Nausibius, Oryzaephilus, Cathartus and Silvanus shows that this is a distinct and homogeneous group.

Laemophloeus liquidus Csy. Figs. 13 and 14.

Aedoeagus of this form, small and rounded. Median lobe (ML) a broad somewhat flattened structure, very irregular, with a median groove on the ventral surface. Median foramen large, rounded, located at the proximal end of the median lobe. Distal end of the median lobe very irregularly formed with the dorsal surface produced at the middle of the anterior margin to form a pointed end. Median orifice ventrad of this point. Internal sac simple, without flagellum. Tegmen consisting of a broad dorsal piece and a smaller basal piece. Dorsal piece broad almost entirely covering the median lobe, only a narrow band around the border chitinous, the central part being membranous, broadly joined to the basal piece. Basal piece short, pointed at the anterior margin; bearing at the distal margin a heavily chitinized area which has two pair of heavy teeth one above the other. The dorsal pair is longer and conceals the ventral pair from a dorsal view. These heavy tooth-like structures are the only structures which can be compared with the lateral lobes of other forms. It seems improbable to me that these structures are homologous with the lateral lobes of Brontes.

The aedoeagus resembles Brontes in its relationship of tegmen to the median lobe, for the large membranous piece is on the dorsal aspect of the aedoeagus and the piece bearing the tooth-like structures is on the ventral surface. The Laemophleous and Brontes aedoeagus may possibly have been derived from a common ancestor which has disappeared. In other respects the aedoeagus is entirely different from the other specimens studied.

Cucujus clavipes Fabr. Fig. 5.

Aedoeagus long and slender, extending almost the whole length of the abdomen. Median lobe (ML) short and tubular with a large oval median foramen on the dorsal surface, and a long flattened median strut (MS) continuing from the ventral margin. Median orifice at the distal end of the median lobe which has two flap-like pieces folded back from the ventral margin into the median lobe; dorsal margin

deeply emarginate at each side so that the median portion is left as a short, narrow, projection. Internal sac (IS) as long as the median strut; containing a flagellum (F) which is almost as long as the internal sac. The basal piece of the tegmen is small, short, and narrowed toward the posterior border. Lateral lobes attached to the posterior margin of the basal piece, tubular in shape, short, each bearing two very long setæ and numerous shorter ones at the distal end. Dorsal piece located on the dorsal aspect of the aedeagus; reduced to a long, slender tegminal strut (IS) which is connected to the basal piece by two long, narrow chitinous bands.

Cucujus clavipes puniceus Mann.

The aedoeagus of this form resembles that of *C. clavipes* very closely in all of the structures as is to be expected in a subspecific form. The aedeagus of *C. puniceus* is distinguished from *C. clavipes* by the fact that the median lobe and lateral lobes are slightly longer in the case of *C. puniceus.*

The exceptional length of the aedoeagus of these two forms immediately sets it off from the forms previously described. Such a length of aedoeagus is only approached by *Catogenus rufus.* Aside from the extreme length of the aedoeagus the small basal piece with the rounded lateral lobes bearing two long setæ and the long tegminal strut are characters which distinctly separate the Cucujid aedoeagus from the aedoeagus of Brontes, Telephanus, and other genera of the family. It becomes clear then that the position of the basal piece on the ventral aspect of the median lobe is a family character common to all of the forms included in the family Cucujidæ.

Pediacius fuscus (Lec.). Fig. 15.

Aedoeagus long but not as slender as in Cucujus. Median lobe long, slightly curved toward the distal end with a membranous area (A) on the ventral surface and at the curve. Proximal portion of the median lobe prolonged and tapering to a rounded point at the proximal end. Median foramen (MF) occupying a large portion of the dorsal side of this prolonged area. Median orifice (MO) large, oval in shape, located on the dorsal surface of the median lobe. Ventral surface rounded and deeply emarginate. Internal sac (IS) large, resting in the trough-like proximal portion of the median lobe, with three areas of short spines; without flagellum. Basal piece forming a rather close fitting cap-piece around the ventral and distal portion of the median lobe, bearing at the end two short rounded lateral lobes. Lateral lobes articulating with the basal piece in socket-like depressions, with setæ at the distal end. Basal piece connected to the broad ventral piece of the tegmen by narrow membranous bands. Dorsal piece broad, tapering to a sharp point, covering a large part of the median foramen.

The tegmen of Pediacius is broader and more completely encloses the median lobe than in Cucujus. In Pediacius the dorsal piece is broader than the median lobe and covers over a large portion of the median foramen and the basal piece encloses the distal portion of the median lobe. In Cucujus the dorsal piece is only a narrow strut-like process, and the basal piece is a very small area on the ventral aspect of the median lobe. The median foramen of Pediacius is also much larger than that of Cucujus. The lateral lobes however are about the same size and articulate in socket-like depressions of the basal piece.

It must be remembered, however, that these likenesses are comparative, for the aedeagus of Pediacius actually measures 1.2 mm. while that of Cucujus measures 4.6 mm. in length.

Catogenus rufus Fab. Fig. 17.

Aedoeagus longer than the abdomen, and very slender. Median lobe tubular, anterior half of the tube straight with a large median foramen at the proximal end. Median strut (MS) on the ventral surface, narrow, longer than the abdomen and doubled back so that the proximal end almost reaches the median lobe. Distal half of the median lobe slightly larger, widest near the point of enlargement, gently curving to a rounded apex. Median orifice a large opening on the ventral surface. Internal sac (IS) about one-half as long as the median strut, with a flagellum which does not quite reach the median foramen. Ejaculatory duct at the apex of the internal sac, very long, small, and coiled in a spiral. Dorsal piece of the tegmen broad and covering the anterior half of the median lobe; trapezoidal in shape, widest at the base, sides straight and converging toward the apex. Basal piece on the ventral aspect of the aedeagus; small, connected to the dorsal piece by short chitinous bands. Lateral lobes flattened, extending slightly beyond the apex of the median lobe.

The broad dorsal piece, the small basal piece and the flattened lateral lobes resembles Brontes more closely than any other form in the family. When the tegmen of the two are compared it will be noted that the dorsal piece of Brontes is more nearly rectangular and that the lateral lobes are more widely separated.

Platisus sp. Fig. 10.

Aedoeagus slightly compressed laterally and about two-thirds as long as the abdomen. The median lobe is divided into a proximal and distal portion by a strong elbow curve. The proximal portion is gently curved, about one-third shorter than the distal portion, and is open on the dorsal surface for its entire length to form the median

foramen (MF). The proximal end of the internal sac (IS) is folded into this open area of the median lobe. The distal portion is also gently curved; produced on the dorsal surface beyond the median orifice to a rounded point. The median orifice is then located on the ventral surface. The internal sac (IS) bears short tubercules at the proximal end, but is without a flagellum. Basal piece (BP) short, located above the median orifice. The tegmen is completed by two narrow, long bands which extend anteriorily from the angles of the basal piece and form a slightly larger area at the elbow curve of the median lobe. The lateral lobes (LL) are short and flattened bearing numerous setæ at the distal end; distinctly separated from the basal piece by a suture

The aedoeagus of this form is slightly compressed laterally and is gently curved so that it rests on the left side with the basal piece and lateral lobes turned toward the left side of the body. I have been unable to observe the position of the aedeagus when in copula, but I have described the basal piece as being ventrad of the median lobe as is the case in other species of Cucujidæ. In other respects the aedoeagus is comparable to that of Pediacius, particularly in the structure of the proximal portion of the median lobe, the long median foramen, and the internal sac with the short tubercules on the proximal portion of the wall.

The question of the orientation of the tegmen is an important one, for, if the tegmen is dorsad of the median lobe instead of ventrad, as I have described it, the aedoeagus would show closer affinities to the Cryptophagidæ than to the Cucujidæ.

NITIDULIDÆ.

Carpophilus pallipennis (Say). Fig. 30.

Median lobe (ML) short and difficult to observe from a dorsal view, though its outline can be determined clearly from a lateral view; dorsal surface prolonged at the distal end with the oval median orifice (MO) on the ventral surface; truncate at the proximal end, with the median foramen (MF) occupying the entire end. Median strut (MS) attached at the dorsal surface of the median lobe, long, and slender with the proximal end slightly enlarged. Internal sac (IS) a simple tubular structure without modifications of any kind. Tegmen (TG) composed of two heavily chitinized pieces (which appear to be homologous with the lateral lobes of the Mycetophagidæ) fused together on the dorsal surface and united on the ventral surface by a short flattened tegminal strut (TS). Median lobe swinging in and out of the lateral lobes in a broad arc being pivoted by a shorter connecting membrane on the ventral surface and a longer membrane on the dorsal surface.

The aedoeagus of this form is peculiar in that the tegmen is a rather large piece fused at the base and divided apically.

Lobiopa setosa Hald. Fig. 34.

Median lobe (ML) short, slightly flattened dorso-ventrally, tapering to a point at the distal end and with the large transverse median orifice on the dorsal surface; truncate at the proximal end. Median foramen large, oval in shape. Median strut (MS) attached at the dorsal surface, slender, about three times as long as the median lobe. Internal sac (IS) extending to near the end of the median strut, with a short flagellum (F) at the proximal end. Tegmen composed of a broad flattened basal piece (BP) on the dorsal side of the aedeagus, connected across the ventral surface by a very short, chitinous band. Basal piece broad, curving around the median lobe at the proximal end; flattened at the distal end, and slightly emarginate. Also two short stiff bristles, and numerous finer setæ. Median lobe swings in and out of the basal piece as in Carpophilus.

Lobiopa setosa has many characters which mark it as a transitional form between Carpophilus and Glistrochilus. In the first place the internal sac in Glistrochilus is simple, in Lobiopa the internal sac has a short flagellum at the proximal end. The side pieces of the tegmen of Carpophilus have moved around more to the dorsal surface, and have almost completely fused in Lobiopa. The median lobe has been lengthened in Lobiopa. The ventral surface of the aedeagus of Lobiopa is produced so that the median orifice is on the dorsal surface instead of on the ventral surface as in Carpophilus.

Glistrochilus obtusus (Say). Fig. 33.

Median lobe short, and sharply curved, flattened at the distal end, and rounded at the proximal end, truncate at the proximal end, with a large median foramen (MF). Median strut (MS) attached at the dorsal surface, very long, and slightly enlarged at the distal end. Median orifice (MO) on the dorsal surface, extending along the curved part of the median lobe almost to the distal end. Internal sac as long as the median strut, with the proximal end enlarged to form a bulbular structure with chitinized structures at the sides. Ejaculatory duct entering at side and projecting into the internal sac. Setæ numerous, arranged in a band at one side of the internal sac. Tegmen consisting of the large Basal piece (BP) and a short chitinous band across the ventral surface which is slightly produced at the center to form a short tegminal strut (TS). Basal piece curved to fit over the median lobe; rounded and somewhat flattened at the distal end, bearing numerous setæ.

The median lobe of this species is very much larger than in Lobiopa and is strongly curved. The internal sac is enlarged at the proximal end and contains a large chitinous area with the ejaculatory duct projecting into the internal sac as a curved piece, while in Lobiopa the flagellum is not very large or com-

plicated in structure. The Basal piece is a single enlarged piece in which the fusion of the side pieces is complete.

Glistrochilus fasciatus (Oliv.).

Median lobe short and curved, but more gradually curved than in *G. obtusus;* median orifice extending to the distal end of the median lobe. Median foramen and median strut as in *G. obtusus.* Internal sac with a large irregular structure at the proximal end, the flagellum. This flagellum almost completely fills the internal sac. Proximal end of the internal sac not enlarged to form a bulb-like structure. Median lobe hinged to the basal piece as in *G. obtusus* and the other two genera of the family.

MONOTOMIDÆ.

Monotoma producta (Lec.). Fig. 35.

Aedoeagus slightly flattened dorso-ventrally and rather broad for its length. Median lobe (ML) short, and broad, truncate at the proximal end with a broad median foramen (MF) which receives the rather large internal sac (IS). A long median strut (MS) projecting from each side of the median lobe; median struts slender, about three times as long as the median lobe. Distal end of the median lobe emarginate at the middle of the ventral surface, which is slightly longer than the dorsal surface. Median orifice (MO) wide, located on the dorsal surface. Internal sac (IS) much longer than the median lobe with a thickened area at about the middle. Ejaculatory duct entering the internal sac and continuing as a spiral flagellum which extends into the internal sac for about one-fifth of its length. Basal piece (BP) flattened, not closing around the median lobe; extending beyond the median lobe and broadly rounded at the apex; without setæ.

The aedoeagus of this form is very much like that of Lobiopa in that both aedoeagi are flattened with short median lobes which are truncate at the proximal end and median orifice on the dorsal surface. The basal piece of both are flattened and shaped much alike though there is a deep median emargination in the basal piece of Lobiopa. Basal piece of Monotoma without setæ. The aedoeagus of Monotoma is readily distinguished by the two slender median struts, the thickened area in the internal sac, and the spiral flagellum at the proximal end.

PHALACRIDÆ.

Phalacrus seriatus (Lec.). Fig. 29.

Aedoeagus rather large when compared with Monotoma. Median lobe (ML) rounded, tubular, decidedly curved near the proximal end, with a very large median foramen (MF) on the ventral surface; dorsal edge produced into a broad truncate area. At the distal end the ventral

edge of the lobe projects beyond the dorsal edge, thus placing the median orifice on the dorsal face at the apex. Internal sac (IS) long, simple, without flagellum or other structures. Basal piece a single chitinized structure which partially encloses the sides of the median lobe; anterior angles connected across the ventral surface by a very short chitinous piece. Median lobe attached to the ventral piece by a short first connecting membrane so that it swings away from the basal piece in a short arc. Dorsal portion of the connecting membrane longer than the ventral portion.

The aedoeagus of this family is distinct from that of the Nitidulidæ in that the median lobe is slender, tubular, not truncate at the proximal end, and without a median strut. They are similar in that the basal piece is a single piece without lateral lobes or setæ. The median lobe is also attached to the tegmen in the same manner in the two families.

EROTYLIDÆ.

Languria bicolor Fab. Fig. 36.

Aedoeagus slightly compressed laterally, almost as long as the abdomen. Median lobe (ML) small, tubular sharply curved near the proximal end. Median foramen a large circular opening at the proximal end of the median lobe. Median strut slender, longer than the median lobe, not suddenly expanded at the end. Distal end of the median lobe truncate, with the oval median orifice (MO) at the extreme end. Internal sac (IS) about twice as long as the median lobe with a slender chitinous flagellum arising at the proximal end which is about half as long as the sac. When at rest the internal sac is withdrawn into the body so that the flagellum is not enclosed by the median lobe. Tegmen consisting of a small basal piece (BP) placed at about the middle of the median lobe; and long narrow arms connecting the small ventral piece (VP) to the basal piece. Basal piece small, short, with two long slender lateral lobes (LL) attached at the distal margin. Lateral lobes bearing a number of long setæ.

The aedoeagus of this form is very different from that of the Nitidulidæ. The median lobe in Languria is much longer, more sharply curved, and is more in the shape of a slender tube that in the Nitidulidæ. The median orifice in Languria is terminal but in the Nitidulidæ it is dorsal in position. The most pronounced difference is that the basal piece in Languria bears two long lateral lobes while in the Nitidulidæ the basal piece is large and forms a cap-piece about the median lobe. The internal sacs of the two forms are quite distinct for in Glistrochilus (the most highly developed Nitidulid) the proximal end is bulb-shaped; contains chitinous pieces, and a short

flagellum. In Languria the internal sac itself is without setæ or other structures except the long slender flagellum.

Erotylus diviiris (Lec.). Fig. 21.

Aedoeagus slightly compressed laterally resembling closely the aedeagus of Languria. Median lobe tubular, curved, truncate at the proximal end, with a long slender median strut (MS) projecting from the dorsal margin. Median foramen (MF) large and circular. Ventral margin of the distal end produced and pointed with the median orifice (MO) on the dorsal surface. Internal sac (IS) only a little longer than the median lobe with the slender flagellum (F) enlarged and divided into two equal prongs at the proximal end. Basal piece (BP) almost as long as the median lobe, and extending around the sides of the median lobe. Ventral piece of the tegmen broad, produced anteriorly so that it almost completely covers the median orifice. Lateral lobes (LL) at the distal end of the basal piece, bearing numerous setæ.

In view of the great diversity of body structure of the two forms Erotylus and Languria it is rather remarkable that the aedoeagi should agree so closely. The general shape and structure of the two are very similar. The median lobe of Erotylus is, however, larger in diameter and is almost straight with the median orifice on the dorsal surface while in Languria the median lobe is smaller, strongly curved with both the median foramen and median orifice at the ends of the median lobe. The tegmen of Languria is much smaller with the lateral connecting pieces very slender and longer than in Erotylus. The lateral lobes are distinctly separated from the basal piece in both genera while they are much longer in Languria than in Erotylus. The internal sac of Erotylus is much shorter than in Languria and the flagellum is branched at the proximal end in Erotylus.

Triplax thoracica (Say). Fig. 20.

Median lobe (ML) tubular, though slightly compressed, laterally, curved toward the middle. Median foramen large covered by the ventral piece. The median orifice (MO) on the dorsal surface, is a large opening occupying a great part of the median lobe. A long slender median strut (MS) extends from the dorsal margin of the proximal end of the median lobe. Internal sac (IS) about as long as the median lobe with a slender bent flagellum (F) attached at the apex. Tegmen consisting of a large basal piece and ventral piece. Basal piece (BP) about two-thirds as long as the median lobe and extending well up around the sides. Lateral lobes short and broad. Ventral piece (VP) broadly connected to the basal piece, produced anteriorly to form a rather broad flat tegminal strut (TS).

The aedoeagus of this form in general resembles that of the two forms previously described. But the broad flat tegminal strut, the bent flagellum, the enlarged proximal end of the median strut, and the very large median orifice are characters in which Triplax differs from Erotylus. The lateral lobes are also shorter than in Erotylus.

Agithus genuinatus (Lec.). Fig. 19.

Median lobe (ML) long and slender, sharply curved near the proximal end and with a large circular median foramen at the proximal end. Median strut (MS) extending from the dorsal edge, slender and slightly expanded at the extreme end. Median lobe (ML) gradually larger toward the distal end, with the dorsal surface slightly produced and pointed, thus placing the median orifice on the ventral surface. Internal sac (IS) slender and simple, without flagellum. Basal piece (BP) long; almost enclosing the sides of median lobe, with shorter rather broad lateral lobes attached at the distal end. Ventral piece slightly produced but not entirely covering the median foramen.

The median lobe of this form is more like Languria in that it is tubular, and strongly curved near the proximal end while Triplax and Erotylus are stouter and less curved. The median strut is expanded at the end in both this form and in Triplax. The other members of the family except Tritoma have a flagellum in the internal sac. Internal sac in Agithus and the other members of the family gradually decreasing in size toward the proximal end so that it is impossible to distinguish where the ejaculatory duct joins the internal sac.

Tritoma humeralis Fabr. Fig. 18.

Median lobe (ML) short, larger in diameter than in *Agithus*, slightly curved, produced at the distal end into a rounded point on the ventral surface, with the sides slanting back toward the dorsal surface. Median orifice (MO) large, located on the dorsal surface of the median lobe. The small median foramen (MF) at the proximal end of the median lobe not occupying the entire area. Median strut (MS) at the dorsal edge of the median lobe, slightly longer than the median lobe, expanded at the distal end. Internal sac (IS) small, without flagellum. Basal piece (BP) about two-thirds as long as the median lobe, sides extending around the median lobe, with two short lateral lobes at the distal end. Ventral piece pointed at the anterior border, extending over the median foramen, and broadly connected to the basal piece.

The aedoeagus of *Tritoma humeralis* is shorter than that of any of the other four genera. The median lobe is short, only slightly curved, and produced at the distal end, resembling

Triplax thoracica. The internal sac is without a flagellum as in *Agithus genuinatus.* Lateral lobes of Tritoma similar to the lateral lobes in *Triplax thoracica.*

The members of the family Erotylidæ are shown to be closely related to each other by the genitalia of the male and form a compact natural group. The genus Languria is also shown to be very closely related to the other members of the family.

CRYPTOPHAGIDÆ.

Antherophagus ochraceus Melsh. Fig. 22.

Median lobe (ML) short, rounded, ventral surface much longer than the dorsal surface, thus placing the median orifice (MO) on the dorsal surface. Proximal end of the median lobe tapering into a broad, slightly curved, median strut (MS) on the dorsal surface, ventral surface with a large oval opening for the reception of the internal sac. The internal sac (IS) without flagellum. Tegmen consisting of three parts, the narrow ventral piece, broad basal piece and lateral lobes. Ventral piece (VP) reduced to a very short chitinous band, which is pointed at the middle and connected to the anterior angles of the basal piece. Basal piece (BP) almost as long as the median lobe with large triangular lateral lobes at the distal end which bear long setæ.

Cryptophagus croceus Zimm. Fig. 12.

Aedoeagus smaller and shorter than in *Antherophagus ochraceus.* Median lobe (ML) short, rounded with the ventral surface longer than the dorsal surface and rounded at the distal end. Median orifice (MO) large, located on the dorsal surface and near the rounded point. Proximal end of the median lobe produced into a large median strut which is gently curved. Internal sac (IS) simple, without flagellum. Basal piece (BP) of the tegmen much shorter than the median lobe and only partially enclosing the median lobe. Lateral lobes (LL) small, triangular pieces attached to the distal end of the basal piece, and bearing short setæ. Ventral piece reduced to a chitinized band which completes the ring around the median lobe.

The aedoeagi of these two genera differ only in details. The basal piece is shorter and the lateral lobes are smaller in Cryptophagus than in Antherophagus. The median strut is curved throughout in Antherophagus while it is almost straight in Cryptophagus. The ventral piece is reduced in both forms to a very short chitinous band which connects the angles of the basal piece.

The Cryptophagid aedoeagus is clearly similar in structure to the Erotylidæ. The median strut in the Crytophagidæ

has become expanded so that it encloses the median foramen while in the Erotylidæ the median strut is a very slender structure. The tegmen is also very similar though the ventral piece is reduced and the lateral lobes are expanded into flattened triangular pieces in the Cryptophagidæ.

ENDOMYCHIDÆ.

Endomychus bigutattus Say. Fig. 24.

Aedoeagus so strongly curved that it is crescent shaped. Median lobe (ML) well chitinized, tubular, with the proximal end slightly expanded, and truncate, thus making the median foramen terminal. At the distal end of the median lobe the ventral margin extends beyond the dorsal edge placing the median orifice on the dorsal surface. Median orifice long, elliptical in shape with the internal sac partially extruded. Internal sac short and tubular with short slender flagellum (F) at the apex. Internal sac not distinctly distinguishable from the ejaculatory duct. Tegmen consisting of a short chitinous piece which encircles the median lobe. An irregular tegminal strut extending from the ventral face of the tegmen, expanded at the end and articulating with the proximal end of the median lobe. No lateral lobes present.

The crescent shaped tubular median lobe and the short tegmen without lateral lobes characterize the aedeagus of this form.

COCCINELLIDÆ.

The aedoeagus of the Coccinellidæ lies on one side with the lateral lobes toward the left side of the abdomen. The curvature of the aedeagus requires that it lie on one side and when extended it turns through an angle of ninety degrees in order to come in contact with the female genitalia. The curvature and bulk of the aedeagus would require some such arrangement. In the extended condition the lateral lobes are dorsad of the median lobe and are described as being dorsal in the following descriptions.

In specimens observed in copula the lateral lobes serve as claspers being placed on the outside of the abdomen of the female. In other families the lateral lobes are supposed by Sharp and Muir to enter the vagina and serve as distensors.

The Coccinellid aedoeagus differs from all the other families of Coleoptera in that it has developed another chitinous area which surrounds the median lobe. This area is definitely a part of the tegmen and I have called it *basal lobe* since it is an

extension of the basal piece of the Tegmen. The basal lobe becomes more and more complex and I have arranged the descriptions in order from the simple to the complex type of structure.

HYPERASPINI.

Hyperaspis signata (Oliv.). Figs. 37 and 38.

Median lobe (ML) long, slender, curved and tubular with the proximal end flattened. Median foramen (MF) a long opening extending the length of this flattened area. Median orifice at the distal end of the median lobe. Internal sac a simple straight tube without flagellum. Tegmen forming a complete ring around the median lobe. Basal piece (BP) heavily chitinized, forming an almost complete circle, which is completed by the tegminal strut (TS) on the ventral side. Tegminal strut slender, articulating with the expanded portion of the median lobe. Lateral lobes (LL) at the sides of the basal piece and appearing to be continuation of the basal piece. Basal lobe (BL) between the lateral lobes and apparently a median extension of the basal piece.

It is this basal lobe upon which Vierhoeff (1893) based his separation of the Coccinellidæ from the remainder of the Coleoptera as the suborder Siphonophora. Figures 38 and 40 show this area to be definitely a part of the tegmen and not the "penis" (which corresponds to the median lobe).

Brachyacantha ursina Fabr. Fig. 39.

Expanded portion of the median lobe subrectangular in shape with the median foramen (MF) extending the length of this area. At the dorsal surface there is a thin chitinous area (A) which is also found in Coccinella. Median lobe tapering to a small opening at the distal end. Basal lobe (BL) broad, not curved around the median lobe, slightly longer than the lateral lobes. Lateral lobes (LL) large and concave. Tegminal strut (TS) attached to the ventral face of the tegmen and articulating with the expanded proximal end of the median lobe.

CHILOCORINI.

Chilocorus bivulnerus (Muls.). Figs. 40 and 41.

Median lobe (ML) long and slender, with the proximal end expanded in such a manner as to form a T with the median lobe. Basal piece (BP) large, and cylindrical. Lateral lobes (LL) slender, extending to the end of the median lobe. Basal lobe (BL) as long as the lateral lobes, pointed at the distal end. Figure 40 also shows the basal lobe to be a continuation of the tegmen and not a part of the median lobe.

COCCINELLINI.

Ceratomegilla fuscilabsis Muls. Fig. 42.

Median lobe (ML) long and tapering to a small distal end. Flattened portion of the median lobe deeply emarginate to receive the tegminal strut. Basal piece (BP) long and circular. Lateral lobes (LL) slender. Basal lobe (BL) broad, curving around the median lobe but not meeting on the mid ventral surface.

Adalia bipunctata (L) Fig 43

Flattened portion of the median lobe subrectangular and slightly emarginate to receive the tegminal strut (TS). Median lobe tapering toward the distal end then suddenly enlarged at the end. Basal piece (BP) short. Lateral lobes (LL) short and slightly curved. Basal lobes (BL) slightly longer than the lateral lobes, sides closely approaching each other on the dorsal surface producing a keel-like structure.

Anatis quadridecimpunctata (Oliv). Fig. 44.

Aedoeagus long and slender. Proximal end of median lobe deeply emarginate, medium sized, irregular in outline. Median lobe (ML) tapering toward distal end and suddenly bent ventrad. Tegmen much smaller than in Coccinella. Lateral lobes (LL) and basal lobe (BL) of equal length. Basal lobe irregular in shape with lateral margins widely separated.

Coccinella perplexa Muk Fig. 45.

Proximal portion of the median lobe very much larger than in Anatis with the median foramen (MF) extending its whole length; tegminal strut fitting into the emargination near the center. Median lobe tapering to a small distal end. Tegmen large with the anterior dorsal surface of the basal piece (BP) prolonged to a sharp point. Lateral lobes (LL) shorter than the basal lobe. Basal lobe (BL) broad with the sides folding around the median lobe, but widely separated on the ventral surface, pointed at the distal end.

Coccinella novemnotata Hbst. Fig 46.

The aedoeagus of this species is longer and less bulky than *C. perplexa.* Proximal end of median lobe (ML) large with a thin chitinized area (A) on the dorsal margin. Median lobe about the same size throughout its whole length. Basal piece (BP) produced at the anterior margin to a point. Basal lobe (BL) longer than the lateral lobes, not extending around the median lobe.

Coccinella quinquenotata Kby. Fig. 47.

Aedoeagus long, and large. Proximal end of the median lobe (ML) expanded transversely, irregular in outline, with the flattened area (A) at the dorsal margin. Median lobe long, becoming slightly larger at the distal end. Basal piece extending further craniad than in the two species just described. Lateral lobes (LL) as long as the Basal lobe

(BL). Basal lobe enlarged and deeply emarginate at the distal end, surrounding the median lobe but not fused on the ventral surface, dorsal surface more heavily chitinized than the lateral surface.

Olla abdominalis plagiata Csy. Fig. 48.

Proximal end of the median lobe (ML) narrowly flattened, extending in a dorso-ventral direction, with a broad emargination for the reception of the tegminal strut (TS). On the dorsal side the thin chitinized area (A) is present as in Coccinella but much smaller. Median lobe (ML) long; about the same size throughout, except near the distal end. Distal end divided into two subequal prongs, the dorsal prong being bent backward over the basal lobe (BL) and fitting into a groove in the basal lobe, ventral prong bent in a ventrad direction and bearing the median orifice (MO). Basal piece produced and pointed anteriorily. Basal lobe long, almost surrounding the median lobe but not fused on the ventral surface, shaped much as the basal lobe in Epilachna. Lateral lobes (LL) as long as the basal lobe, expanded at the distal end.

The members of the tribe Coccinellini show clearly a gradual increase in complexity of the aedoeagus from *Ceratomegilla fuscilabris* through the series in the order of the above descriptions to the larger aedeagus. And more complex condition displayed in *C. quinquenotata* and *Olla abdominalis.* The enlarged distal end of the median lobe of *Adalia bipunctata* may be an evagination of the internal sac. It is a constant condition for several specimens were examined. *Olla abdominalis plagiata* definitely belongs to the tribe Coccinellini but it also suggests certain tendencies toward Epilachna. Such characters as the length of the median lobe, basal lobe, and lateral lobes show resemblances to the same characters in Epilachna.

HIPPODAMINI.

Hippodamia parenthesis (Say). Fig. 51.

Median lobe (ML) curved very sharply near the proximal end, slightly expanded on the ventral side and having the tegminal strut (TS) rest against this expansion. Median foramen circular and at the proximal end of the median lobe. A small flap-like projection (A) extends from the ventral margin. Median lobe about the same size throughout except near the distal end where it suddenly tapers to a small median orifice (MO). Basal piece (BP) large, and pointed on the dorsal surface, with a short stout tegminal strut (TS) projecting from the ventral surface. Tegminal strut expanded at the distal end and emarginate to form a groove for the median lobe. Lateral lobes (LL) broad Basal lobe (BL) extending around the median lobe and fused on the ventral surface thus completing a second ring or tube around the median lobe. Dorsal and lateral surfaces of the basal lobe well chitinized.

Hippodamia convergens (Guer.). Fig. 52.

Median lobe (ML) shaped much like that of *H. parenthesis;* not expanded at the proximal end. Basal piece (BP) produced to a point anteriorly, with the basal lobe extending around the median lobe and completely fused on the ventral surface to form the second chitinous ring around the median lobe. On the lateral surfaces this structure is deeply emarginate at the distal end, with the dorsal and ventral surface sharp pointed. Tegminal strut (TS) enlarged toward the distal end and grooved to receive the median lobe. Lateral lobes (LL) narrow.

Hippodamia tridecempunctata (Linn). Fig. 53.

The aedoeagus of this form is very irregular in shape. Median lobe as in the two species above. Basal piece (BP) large, not produced anteriorly. Basal lobe large, tubular, and completely surrounding the median lobe, emarginate at the distal end Lateral lobes (LL) broad and without setæ.

Casey (1899) and others place Hippodamia, Ceratomegilla and other genera in the tribe Hippodamini. Leng (1920) and Daborensky (1926) place all of these genera in the tribe Coccinellini. The following characters of the aedoeagus however are sufficient to separate Hippodamia as a distinct tribe: proximal end of the median lobe not expanded, median orifice terminal and rounded, proximal end of median lobe with a small flag-like projection from the ventral surface, basal lobe completely fused on the ventral surface.

EPILACHNINÆ.

Epilachna borealis (Fab.). Fig. 49.

Median lobe (ML) curved into an S-shaped slender tube about the same size throughout, proximal end slightly expanded. Basal piece (BP) truncate at the margin with long slender lateral lobes (LL). Tegminal strut (TS) short grooved for articulating with the proximal end of the median lobe. Basal lobe (BL) long, fitting closely around the median lobe, sides not fused on the ventral surface to complete the tube.

Epilachna corrupta (Muls.). Fig. 50.

The proximal end of the median lobe of this species is not expanded but a small projection from the ventral side of the median lobe serves as a stop for the tegminal strut. Basal lobe more strongly curved and the tegminal strut more irregular in shape than in *E. borealis.*

The aedoeagus of the two species of Epilachna differ quite markedly from that of the other Coccinellidæ in the reduction of the expanded proximal end of the median lobe, and the

recurved condition of the median lobe. This second curve of the distal portion of the median lobe also requires a like curve of the basal lobe in *E. corrupta* for the basal lobe fits more closely around the median lobe than in *E. borealis*. In the tegmen other very distinct differences will also be noticed. First, the tegmen as a whole is slender and much less bulky than in the species of Coccinella and Hippodamia. Second, the anterior border of the basal piece is not prolonged and pointed but is shorter and truncate in Epilachna. Third, the lateral lobes are longer and narrower in Epilachna than in Coccinella.

The structure of the aedeagus of Epilachna and Hippodamia indicates that there were two lines of development from the Coccinella aedoeagus. *Olla abdominalis plagiata* shows a tendency toward the slender condition with a reduction of the flattened proximal end of the median lobe and a lengthening of the basal lobe to resemble the basal lobe of Epilachna somewhat. In the genus Hippodamia the aedeagus remains broad with an expanded piece, and with a very large, irregular, and tubular basal lobe. The lateral lobes also remain broad and short as in Coccinella. Thus Epilachna may be derived from a form like *Olla abdominalis plagiata* while Hippodamia may be derived from a form like Coccinella.

GENERAL DISCUSSION.

The structure of the aedoeagi described are such that they may be divided into four groups. The first group is characterized by the tegmen not forming a complete ring around the median lobe. The tegmen is also on the ventral aspect of the median lobe. This group is represented by the Mycetophagidæ. In the second group the tegmen forms a complete ring around the median lobe and the lateral lobes attached to the basal piece are on the ventral aspect of the median lobe. The Cucujidæ are an example of this type of aedoeagus. In the third group the basal piece is absent, and the lateral lobes are fused to form a single chitinous area on the dorsal aspect of the median lobe. The Nitidulidæ, Monotomidæ, and Phalachridæ belong to this group. The fourth and last group is characterized by the aedoeagus lying on its side with the tegmen forming a ring around the median lobe, and the lateral lobes present in a dorsal or latero-dorsal position. To this group belong the Erotylidæ, Cryptophagidæ, Endomychidæ, and Coccinellidæ.

Sharp and Muir have applied the term trilobe to the first type of aedoeagus. Besides the characters given above the aedoeagus of this type has the lateral lobes attached to the basal piece by a thin membrane which allows them to swing away from the median lobe in a slight arc. The basal piece is usually broad and is attached to the median lobe by a short membrane which causes the two parts to move as one. The median lobe is usually a simple straight tube enclosing an unmodified internal sac. This type of aedoeagus is considered most primitive because of the simplicity of the median lobe, and because transitions from this type to a more complicated type is easier than from any other type of aedoeagus. The family Mycetophagidæ is the only family I have studied which possesses this type of aedoeagus.

The second type of aedoeagus represented by the Cucujidæ is of a rather heterogeneous nature. The genera Hemipeplus, Inopeplus and Prostomis in fact have an aedoeagus which relates them directly to the Mycetophagidæ, for the tegmen is not completed around the median lobe. If we consider the aedoeagus of these genera alone they should be separated as a distinct family from the Cucujidæ. But if we examine the body characters of these three genera it is impossible to find characters which will separate them from the Cucujidæ. The aedoeagus also fails to furnish characters which would support placing Hemipeplus, Inopeplus, and Prostomis with Laemophloeus to form the family Laemophlidæ of Böving. The aedoeagus of Laemophloeus differs from that of the first three forms in every respect, while according to the larval characters Hemipeplus and Inopeplus should be included in the same subfamily with Laemophloeus.

In the genus Dendrophagus we have a very good example of how the bilobed type of aedoeagus may be derived from the trilobe type. The lateral lobes are not separated from the large basal piece by a membrane but are solidly fused to it, and a short chitinized band is formed across the dorsal surface so that the tegmen completely encircles the median lobe. Then it is not necessary to imagine the lateral lobes moving around to the dorsal surface to derive the cucujid aedeagus from the trilobe type. The connecting membrane between the median lobe and the tegmen has become lengthened to allow movement of the median lobe in the tegmen which completes

the fundamental changes required for the production of the cucujid type of aedeagus.

The short dorsal piece in Dendrophagus is produced anteriorily in Brontes concomitant with a reduction of the basal piece and a separation of the lateral lobes. These changes produce an aedeagus which resembles Dendrophagus very little superficially. It must be remembered, however, that the lateral lobes are still on the ventral aspect of the aedeagus. The shape of the median lobe and internal sac of these two forms is also very different, more different in fact than the same structures in the families Nitidulidæ and Monotomidæ. There is certainly a great enough diversity in the genitalia to justify separating Brontes and Dendrophagus as distinct families. The body characters or larval characters, however, do not indicate a wide enough separation of the two genera to justify separate family rank.

When we consider the tegmen of Telephanus we find that it may be readily derived from some form like Brontes by a lengthening of the chitinous connections between the dorsal and ventral parts. The median lobe in Brontes is also simple enough to allow the assumption that the two came from a common ancestor. Furthermore, the aedoeagus of Telephanus is more closely related to Brontes than Brontes is to Dendrophagus. Then if we follow Böving in placing Telephanus in the family Silvanidæ, Dendrophagus should also be placed in a new family

The aedoeagus of Oryzaephilus and Nausibius represents a very high degree of specialization of the median lobe, but the general structure of the tegmen resembles that of Telephanus so closely that they may be placed together.

The aedoeagi of Silvanus and Cathartus are very small, but the dorsal portion of the tegmen resembles that of Brontes very closely. The position of the lateral lobes and the shape of the median strut shows Silvanus and Cathartus to be a member of the same group as Telephanus.

In the genus Laemophloeus the aedoeagus is flattened dorsoventrally with a broad dorsal piece covering the median lobe, and the tooth-like structures representing lateral lobes on the ventral aspect, as in Brontes. The small size and very peculiar structure of the aedoeagus makes it difficult to determine the position of this genus but it seems least out of place near Brontes.

In the case of Cucujus the basal piece and lateral lobes are on the ventral aspect of the aedoeagus as in the other members of the family. The very long slender aedoeagus makes it difficult to place this genus with certainty. It is possible that Cucujus is also derived from some form like Brontes. A great lengthening of the aedoeagus is the principal change required.

The aedoeagus of Pediacius resembles that of Cucujus in many respects, particularly in the tegmen, but the difference in length of the two aedoeagi causes the two aedoeagi to appear rather distantly related.

Catogenus resembles Brontes in the size, shape and position of the parts of the tegmen very closely.

In the case of Platisus the determination of its affinities depends upon the view taken as to the position of the tegmen. I have described the tegmen as ventrad of the median lobe because the other characters of the aedoeagus show it to be related to Pediacius which has the tegmen ventrad of the median lobe. If, however, the tegmen is dorsal Platisus is closely allied to the Cryptophagidæ.

The family Cucujidæ includes a group of genera which show such a wide variation in the structure of the aedoeagus that it is impossible to determine with any degree of certainty the affinities of the various genera. If we begin separating the genera into families as indicated by the genitalia it would become necessary to give practically every genus family rank. Then we are confronted with the alternative of leaving the family as a conglomerate of widely separated forms or giving each genus family rank. I have also attempted to arrange the genitalia in groups which would correspond to Böving's arrangement of the larvæ.

Such a division of the family upon larval characters would require the separation of the genera Silvanus, Cathartus, Oryzaephilus, Nausibicus, and Telephanus as a distinct family while Dendrophagus and Brontes would remain in the same subfamily. If the genitalia are considered it is obvious that Dendrophagus differs from Brontes as much if not more than Telephanus differs from Brontes. The same thing is true of the genera Cucujus, Pediacus and Platisus, each being distinctly different from the other. These genera would all be placed together when the larval and adult characters are considered. But the genitalia of Platisus and Cucujus show a much greater

difference than the genitalia of Cryptophagus and Erotylus. When the body characters are considered it is impossible to find characters which will separate Platisus from Cucujus or Dendrophagus from Brontes as separate families. Where such conditions prevail it seems that less confusion will result if we do not attempt to separate the old family Cucujidæ. So I propose to recognize it as a very primitive family in which a great many intermediate forms have disappeared.

The third group represented by the Nitidulidæ, Monotomidæ and Phalacridæ is characterized by having the greater portion of the tegmen on the dorsal aspect of the aedoeagus.

The aedoeagus of Carpophilus represents the primitive type of this group. The tegmen of Carpophilus may be derived from the trilobe type of aedoeagus by three changes; first the disappearance of the basal piece. This is not an impossible change because a similar change takes place in Brontes. Second the lateral lobes are fused on the dorsal surface to form a new basal piece. The fusion of the lateral lobes on the dorsal surface is a natural result of the reduction of the basal piece in order to hold the tegmen together. This is not a great step because the lateral lobes approximate each other on the dorsal surface. Third, the formation of the tegminal connection on the ventral surface is probably the result of chitinization of the membranes which connects the aedeagus to the body.

In Lobiopa the fusion of the lateral lobes on the dorsal surface is almost complete with only a slight emargination at the apex to indicate the separated condition in Carpophilus. Accompanying this fusion on the dorsal surface the tegmen has drawn away from the mid-ventral line leaving a short connecting piece across the ventral surface.

Glistrochilus represents the stage in which the fusion is complete. In this form the tegmen is a single large cap-piece fitting rather closely over the curved dorsal surface of the median lobe.

The internal sac of these three genera also gradually increases in complexity. Like Mycetophagus the internal sac of Carpophilus is undifferentiated. In Lobiopa there is a short simple flagellum at the proximal end. Finally in Glistrochilus the ejaculatory duct empties upon a short curved flagellum, the end of the internal sac is bulb-shaped, and numerous setæ are present.

The tegmen of Monotoma is broad and flattened on the dorsal surface without an emargination at the apex, and the ventral portion of the tegmen is produced anteriorily so that it is much longer than in Lobiopa. The structure of the median lobe and internal sac of the Monotomidæ and Nitidulidæ is quite different but the structure of the tegmen in the two families show such strong resemblances that I believe them to be closely related.

The Phalacridæ also belong in this group, and was probably derived from some form like Lobiopa. The basal piece of Phalacrus like Monotoma is not emarginate at the apex, but is a single piece covering the greater part of the dorsal surface of the median lobe.

The fourth group composed of the Cryptophagidæ, Erotylidæ, Endomychidæ, and Coccinellidæ, is distinguished by having the aedoeagus widely curved and resting on the left side within the abdomen. When the aedoeagus is extruded it turns through an angle of ninety degrees as described in the case of the Coccinellidæ, so that the tegmen is dorsad of the median lobe in the four families of this group.

The families included in this group show very little affinity for the two preceding groups, but the three agree, however, in one respect. The tegmen, though variable in shape, position and structure forms a complete ring around the median lobe.

The characters used to distinguish this group bring together four families which vary widely in the shape of the tegmen and median lobe. In the Erotylidæ and Cryptophagidæ the basal piece covers a greater part of the median lobe. Both families have median struts extending from the dorsal margin of the median lobe. The internal sac in both families is tubular and continuous with the ejaculatory duct but the sac of the Cryptophagidæ represents the simpler condition. In this family the flagellum is not present while in the Erotylidæ, with only two exceptions, the flagellum is present as a stout tubular structure, which is branched at the proximal end in Erotylus.

In the case of the Endomychidæ the tegmen is reduced to a chitinous band which encircles the median lobe, and is without any indication of the lateral lobes. Like the Cryptophagidæ and Erotylidæ the internal sac is continuous with the ejaculatory duct, and like the Erotylidæ it contains a tubular flagellum.

The Coccinellidæ are distinct from the other families in developing the extra basal lobe on the tegmen. In forms figured by Sharp and Muir and in *Hyperaspis signata* the basal lobe is a simple area about as long as the lateral lobes. This piece gradually becomes larger and more complex until it meets on the ventral surface in Hippodamia to form a complete tube around the median lobe. The median lobe in the Coccinellidæ is also specialized in a different direction from the other Coleoptera. The expanded proximal end of the median lobe occurs in all of the genera except Hippodamia. This area is broadly open to receive the small simple internal sac and is attached to the tegminal strut by muscles.

Verhoeff (1895) considered the presence of this tube to be of such importance that he proposes that the Coccinellidæ be placed in the suborder Siphonophora and all the other Coleoptera in the suborder Asiphona. Verhoeff's conclusions result as a different conception of the structure of the aedeagus. The term "penis" as used by Verhoeff is equivalent to the term "median lobe" of Sharp and Muir. Verhoeff considers the basal lobe to be the "penis" enclosing a structure he calls the "Siphon." The basal lobe is a part of the tegmen and is not an independent tube. Figure 38 and 40 show this structure to be clearly a part of the tegmen enclosing the median lobe. Then the Coccinellid aedoeagus is not composed of three rings as Verhoeff thought and his division of the Coleoptera can not be maintained.

EXPLANATION OF ABBREVIATIONS.

BP......Basal piece.	ML.....Median lobe.
BL......Basal lobe.	MO.....Median orifice.
CM_1. ...First connecting membrane.	MS.....Median strut.
CM_2. ...Second connecting membrane.	LL......Lateral lobes.
DP......Dorsal piece.	SP......Spicule.
EJ......Ejaculatory duct.	TG.....Tegmen.
F.......Flagellum.	TS......Tegminal strut.
IS. .....Internal sac.	9SG.....Ninth abdominal segment.
MF.....Median foramen.	10SG....Tenth abdominal segment.

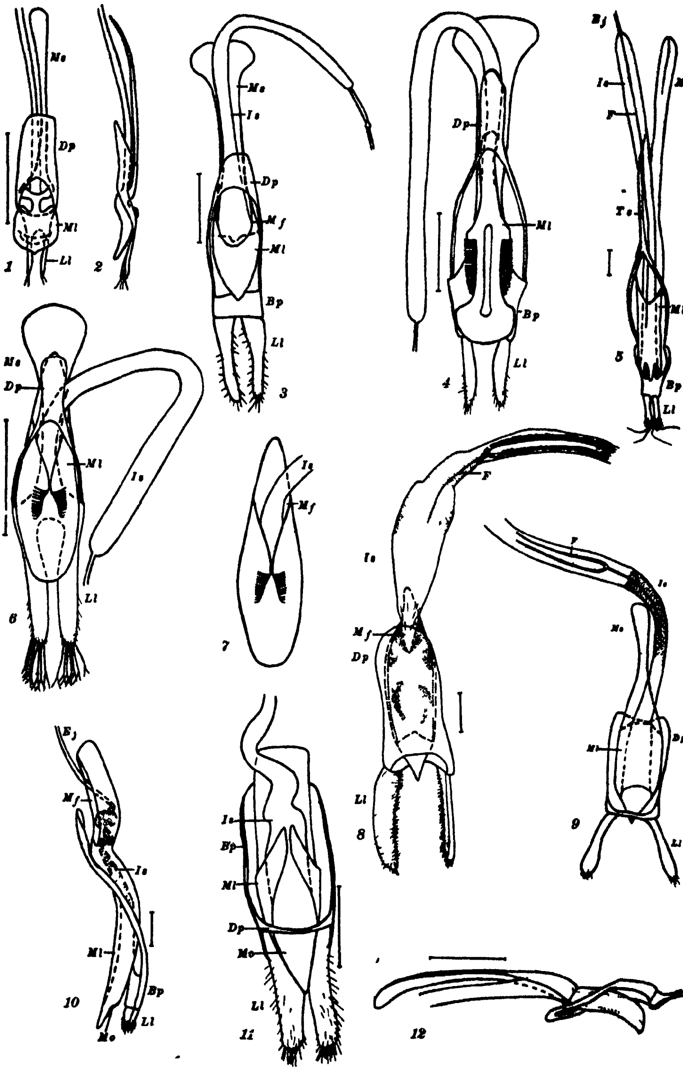


Fig.
1. *Cathartus opaculus* Lec. Dorsal view.
2. *Cathartus opaculus* Lec. Side view.
3. *Telephanus velox* Hald. Dorsal view.
4. *Nausibius clavicornis* (Kug.). Dorsal view.
5. *Cucujus clavipes* Fabi. Dorsal view.
6. *Oryzaephilus surinamensis* (L.). Dorsal view.

Fig.
7. *Oryzaephilus surinamensis* (L.). Median lobe.
8. *Brontes dubius* Fabi. Dorsal view.
9. *Brontes planatus* (L.). Dorsal view.
10. *Platicus* sp. Side view.
11. *Dendrophagus Cygnaei* Mann. Dorsal view.
12. *Cryptophagus croceus* Zimm. Side view.

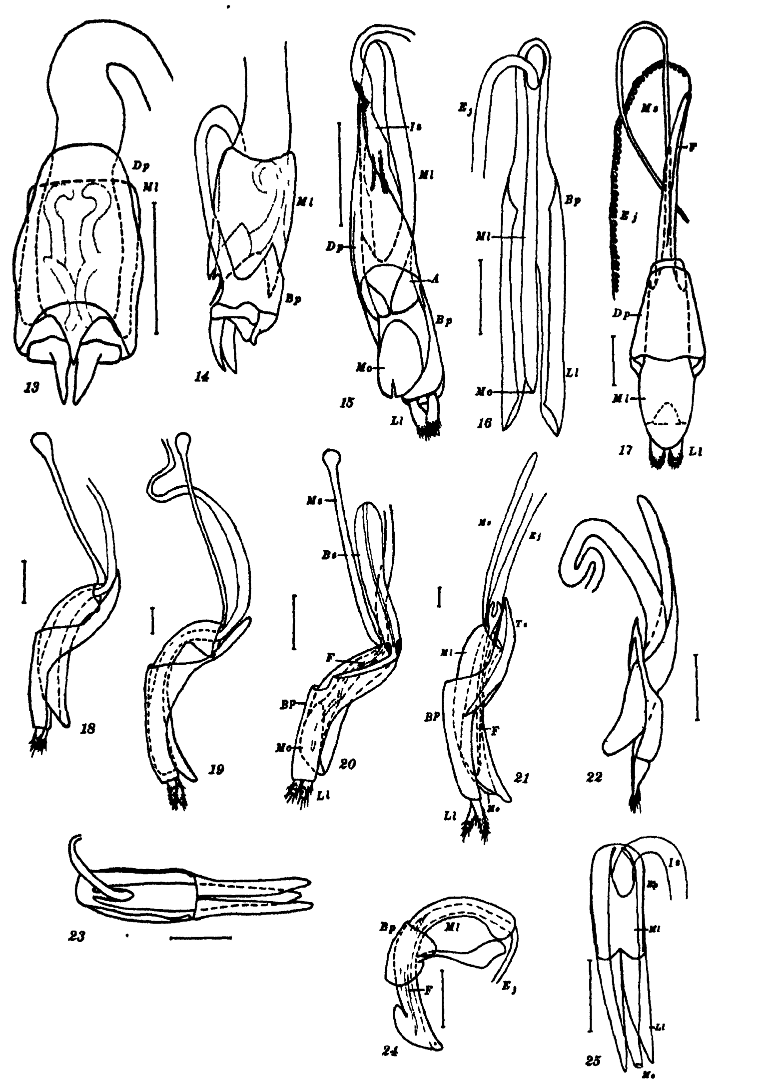


Fig.
13. *Laemophloeus liquidus* Csy. Dorsal view.
14. *Laemophloeus liquidus* Csy. Side view.
15. *Pediacus duscus* Lec. Dorsal view.
16. *Hemipeplus marginipennus* Lec. Dorsal view.
17. *Catogenus rufus* Fabr. Dorsal view.
18. *Tritoma humeralis* Fabr. Side view.
19. *Agithus genuinatus* Lec. Side view.

Fig.
20. *Triplax thoracica* Say. Side view.
21. *Erotylus divirris* Lec. Side view.
22. *Antherophagus ochraceus* Melsh. Side view.
23. *Typhoe fumata* (L.). Dorsal view.
24. *Endomychus biguttatus* Say. Side view.
25. *Mycetophagus flexuosus* Say. Dorsal view.

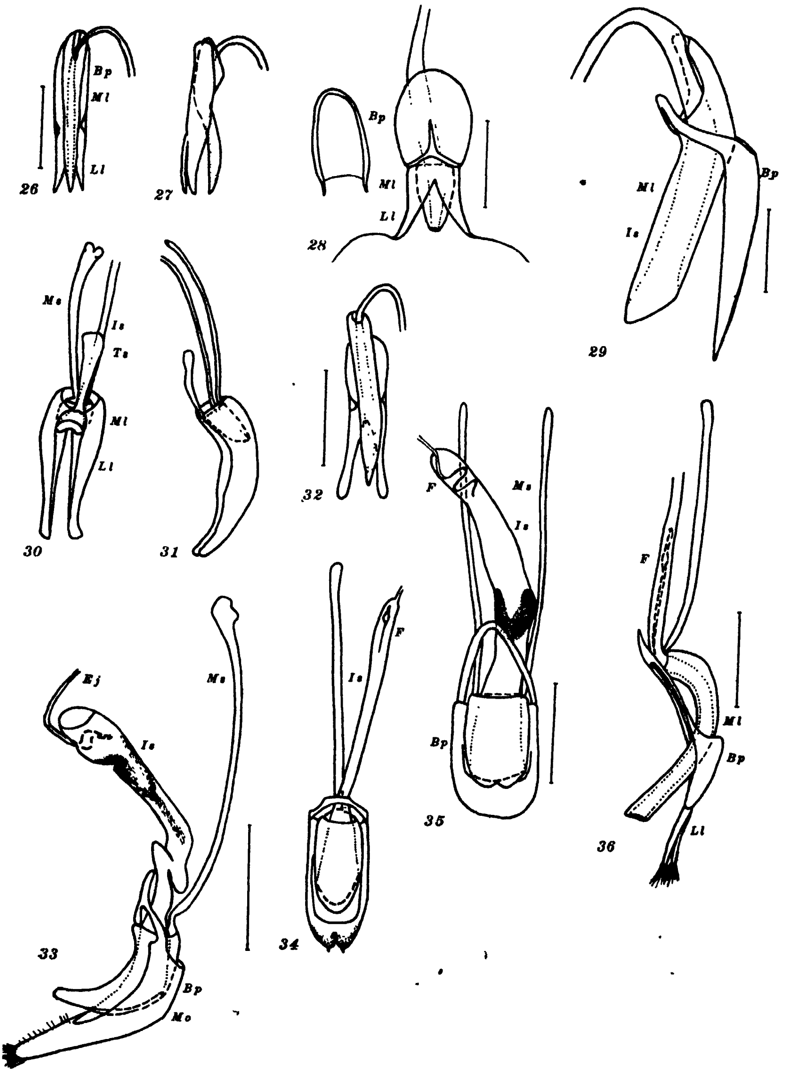


Fig. 26. *Inopeplus immunda* Reit. Dorsal view.
Fig. 27. *Inopeplus immunda* Reit. Side view.
Fig. 28. *Prostomis mandibularis* Fabr. Ventral view.
Fig. 29. *Phalachrus seriatus* Lec. Side view.
Fig. 30. *Carpophilus pallipennis* (Say). Dorsal view.
Fig. 31. *Carpophilus pallipennis* (Say). Side view.
Fig. 32. *Inopeplus reclusa* Lec. Dorsal view.
Fig. 33. *Glistrochilus obtusus* (Say). Side view.
Fig. 34. *Lobiopa setosa* Hald. Dorsal view.
Fig. 35. *Monotoma producta* Lec. Dorsal view.
Fig. 36. *Languria bicolor* Fabr. Side view.

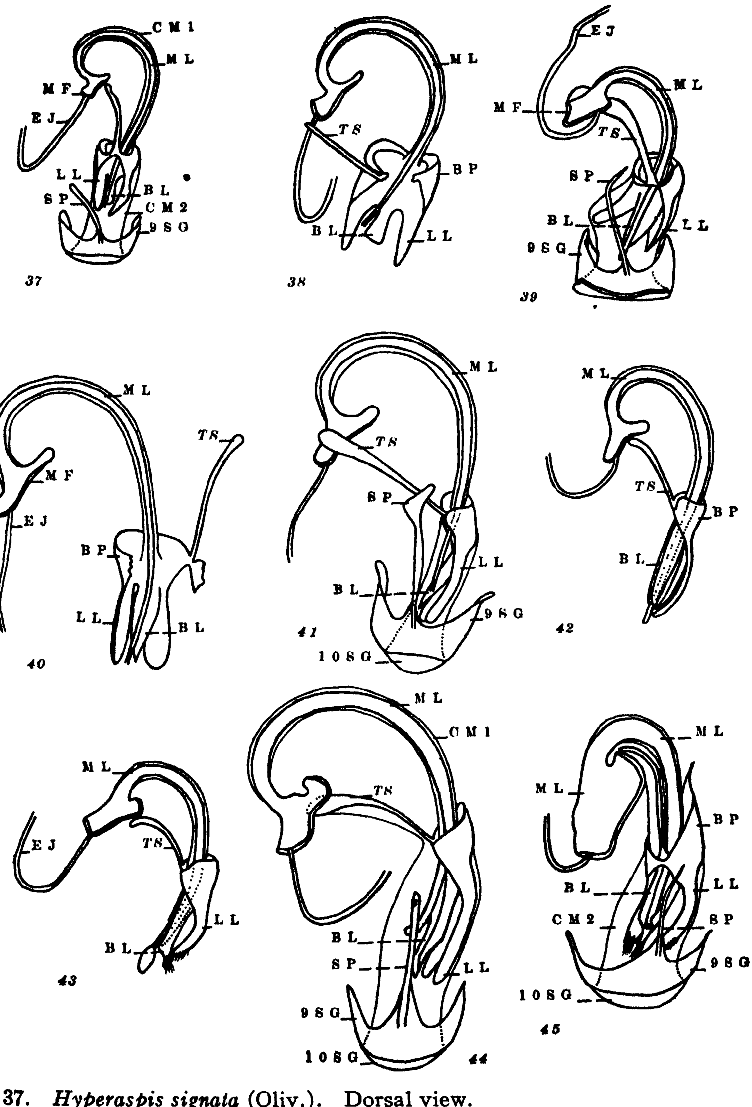


Fig. 37. *Hyperaspis signata* (Oliv.). Dorsal view.
Fig. 38. *Hyperaspis signata* (Oliv.) with the tegmen pulled apart to show the basal lobe.
Fig. 39. *Brachyacantha ursina* Far. Dorsal view.
Fig. 40. *Chilochorous bivulnerus* Muls. with the tegmen pulled apart to show the basal lobe.
Fig. 41. *Chilochorous bivulnerus* Muls. Side view.
Fig. 42. *Ceratomegilla fuscilabris* Muls. Side view.
Fig. 43. *Adalia bipunctata* (L.). Side view.
Fig. 44. *Anatis quadridecempunctata* (Oliv.). Side view.
Fig. 45. *Coccinella perplexa* Mubs. Side view.

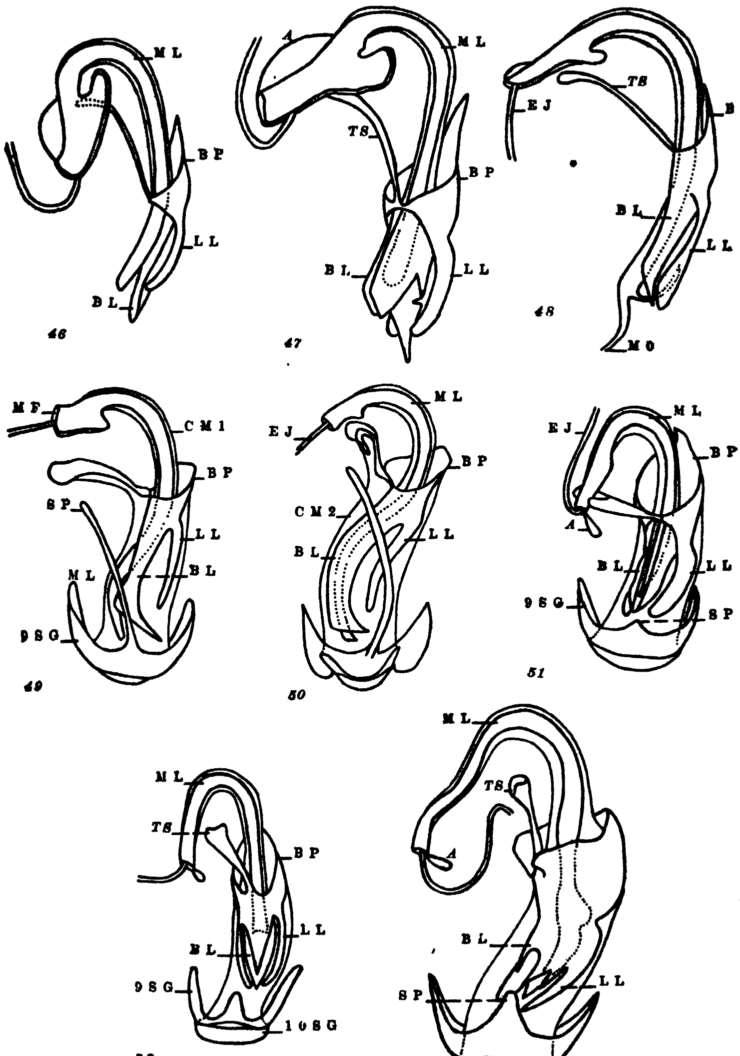


Fig. 46. *Coccinella novemnotata* Hbst. Side view.
Fig. 47. *Coccinella quinquenotata* Kby. Side view.
Fig. 48. *Olla abdominalis plagiata* Csy. Side view.
Fig. 49. *Epilachna borealis* Fabr. Side view.
Fig. 50. *Epilachna corrupta* Muls. Side view.
Fig. 51. *Hippodamia parenthesis* (Say). Side view.
Fig. 52. *Hippodamia convergens* (Guen.). Side view.
Fig. 53. *Hippodamia tridecempunctata* (L.). Side view.

SECTION II

Comparative Study of the Venation of the Cucujidae and Related Families.

The wing veins of the Coleoptera present a problem upon which there has been little agreement by those who have attempted to homologize the venation. This disagreement has arisen because of several reasons, the chief reason being the very unique and complicated course of the veins, which requires very much more study in order to reach correct conclusions than is required by other orders of insects. This unique form of venation is further complicated by the transverse folding of the wings which interrupt the course of the veins and cause distortions that make it very difficult to compare the coleopterous venation with that of other orders.

In the first attempt to use the ontogenetic method of study cerambycid pupæ were used. These forms are very highly specialized and the tracheation no longer shows the course of venation development. Several workers have been thrown off by the theory of alternate convex and concave veins as applied to the Lepidoptera by Adolph (1880).

Burmeister (1842) first used the venation of the second pair of wings in systematic studies when he showed that the Carabidæ, Paussidæ, Dytiscidæ and Gyrinidæ possessed common characters of wing venation. After a study of the wing venation Otto Roger reached the conclusion that the Malacoderms were an ancient group from which all Coleoptera are derived except Adephaga which had previously branched off.

Ganglbauer (1899) recognized three types of wing venation in the Coleoptera, the first type of venation being characterized by having a large number of longitudinal veins running the length of the wing, and a number of cross-veins. Near the posterior extremity of M and Cu two mediocubital crossveins form a closed cell, the oblongum, which is constant in this first type of wing. This type of venation is limited to the caraboid families. The second type of venation or Staphylinoidean type is distinguished by the complete disappearance of crossveins and the basal portion of vein M. This type of venation is derived from the caraboid type by both Ganglbauer and Kolbe (1901). Lameere (1900) believed this second type

to have arisen from the Cantharoidean type of venation and consequently his arrangement of the families is influenced by this belief. The third type of venation or Cantharoidean type is defined by the disappearance of the basal portion of the medius and the curved hook-like connection which this vein makes with the cubitus. Vein R_2 also appears as a recurrent of R. It is this third type of venation which is characteristic of the families included in this study.

In 1915 Kuhne studied the tracheation of the pupæ of seven genera and disagrees with Comstocks (1899) as to the homology of the costo-radial group of trachea.

d'Orchymont (1921) made general studies of the adult wings of the Adephaga and Polyphaga for the purpose of working out a homologous system of the venation. Since d'Orchymont leaves the tracheation of the pupæ out of consideration Forbes (1922) believes that his results are only half correct and proposes another interpretation of the wing veins. Even Forbes' paper leaves the determination of the anal veins a difficult problem. In such forms as Brontes and Platisus the vein next Cu is independent of 2A and is considered to be 1A. In other forms such as Catogenus and Pediacius this same vein appears as a strong one branching from 2A. This condition may be explained on the grounds that 1A has changed its course so as to follow the course of 2A for a space and has again separated from 2A toward the margin. Such a condition is displayed by *Dermestes marmoratus* (Forbes, Fig. 36). *Dermestes marmoratus*, however, is not a transitional form between Brontes and Catagenus but is introduced here to show that such a condition occurs in the Coleoptera.

Martinov (1925) has suggested that the fourth anal of the Coleoptera is homologous with the jugum of the Mecoptera and has been included by the Coleoptera in the anal lobe to support this increase in wing expanse.

EROTYLIDÆ.

The venation of all the genera of the family Erotylidæ (Figs. 68, 73 and 75) is a uniform type of venation which does not vary among the genera as it does among the genera of other families. The Erotylid wing displays more of the primitive characters than any other form included in this study. The radial sector and radial recurrent are present, with a very short indication of the radio-medial crossvein. The first anal is also present with a cross vein to the vein Forbes labels $2A_2$. The presence of the wedge cell is also a primitive character. In

these lower forms the anal lobe is less definitely separated from the anal area than in the forms in which the first anal vein and wedge cell have disappeared. The fourth anal vein is also stronger in these forms. The broadly attached anal lobe and strong 4A may then be considered primitive.

MYCETOPHAGIDÆ.

In the Mycetophagidæ (Fig. 66 and 76) we have a general plan of venation similar to the Erotylidæ. *Mycetophagus punctatus*, Fig. 76, has the wedge cell present though vein $3A_1$ shows distinct signs of

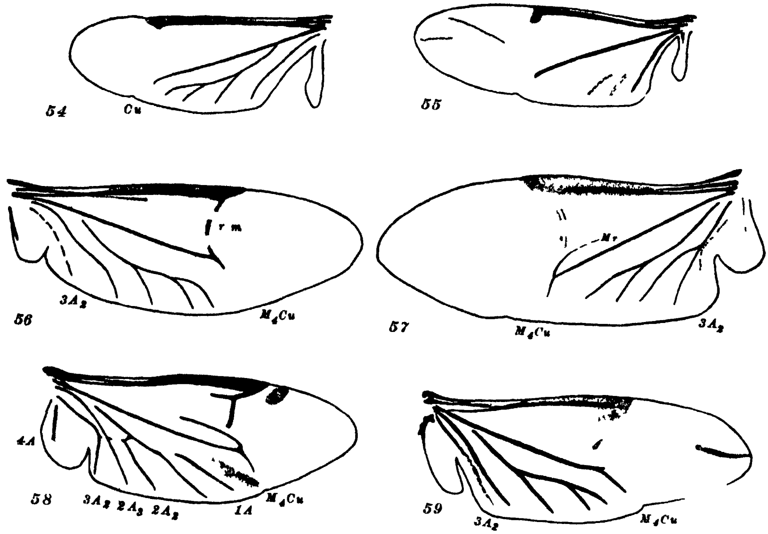


Fig. 54. *Oryzaephilus surinamensis* (L.).
Fig. 55. *Silvanus bidentatus* Fabr.
Fig. 56. *Telephanus velox* Hald.
Fig. 57. *Pediacus fuscus* Er.
Fig. 58. *Brontes dubius* Fabr.
Fig. 59. *Nausibius clavicornis* (Kug.).

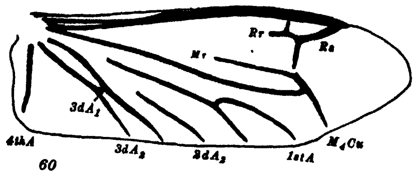
disappearance. This vein has completely disappeared in *Mycetophagus flexuosus* (Fig. 66), and vein 1A is not attached to the cubitus as in *Mycetophagus punctatus* and the Erotylidæ. The radial sector, radial recurrent and radio-medial crossvein show a distinct relationship to that of the Erotylidæ, particularly when *Mycetophagus punctatus* (Fig. 76) is compared with *Triplax flavicollis* (Fig. 75). The Mycetophagidæ also show little tendency toward separation of the anal lobe from the anal region of the wing. The Mycetophagidæ and Erotylidæ are distinctly separated from the other forms by the fact that 1st A is more closely associated with Cu.

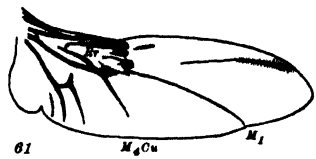
CUCUJIDÆ.

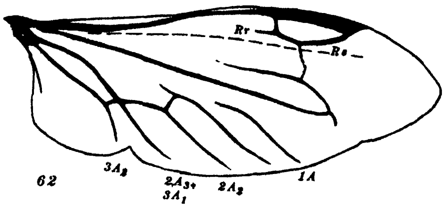
In the family Cucujidæ the venation of the various genera, though variable, shows some characters which are similar, or the modification may be explained as a reduction of the number of veins from a primitive type.

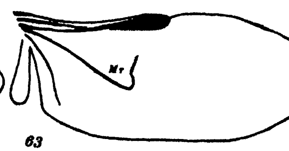
The venation of *Cucujus clavipes* (Fig. 60) probably represents the most primitive condition of the venation found in the family Cucujidæ. The reasons for giving it the primitive position are as follows. First, the radial region closely resembles the same area in the Erotylidæ. Second, the radio-medial cross-vein is still distinct in this form. Third, the anal lobe is broadly attached to the wing and the fourth anal vein is strongly developed.

In this genus the vein $3A_1$ fuses at the base with $3A_2$ and at about the middle of the vein crosses over to vein $2A_3$. The vein $2A_2$ is short and shows no basal connection with the other veins. Vein 1A branches from $2A_1$.









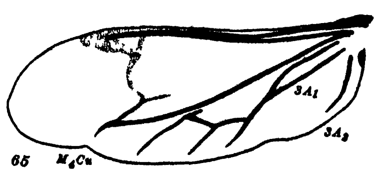


Fig. 60. *Cucujus clavipex* Fabr.
Fig. 62. *Platisus* sp.
Fig. 64. *Catogenus rufus* Fabr.
Fig. 61. *Glistrochilus obtusus* (Say).
Fig. 63. *Laemophloeus liquidus* Csy.
Fig. 65. *Prostomis mandibularis* Fabr.

Platisus (Fig. 62) differs from Cucujus in the following respects: 1A not branching from $2A_1$; $2A_2$ branching from $2A_3$ with a cross-vein between $2A_2$ and $2A_1$; radio-medial cross-vein obsolescent. On the other hand, it resembles Cucujus very closely in the radial area and the vein $3A_1$ is present as a cross-vein between $2A_3$ and $3A_2$.

In *Catogenus rufus* (Fig. 64) vein $2A_2$ branches from $2A_3$ and is connected to $2A_1$ by a cross-vein as in Platisus. The radial recurrent is absent but the radio-medial cross-vein is strong. Vein $3A_1$ is absent in this genus.

The venation of *Brontes dubius* (Fig. 58) resembles that of Cucujus in the radial area but in the anal region the venation is markedly divergent from that of Cucujus. The vein $3A_1$ is only represented by a

short stub from $3A_2$ and the distal part of $2A_2$ is separated from $2A_3$ but the cross-vein between $2A_2$ and $2A_1$ is intact. The vein 1A is unattached at the base as in Platisus.

In *Dendrophagus cygnaei* the anal area resembles that of Telephanus while the radial area is like that of Brontes.

In *Pediacius fuscus* (Fig. 57) the radial veins have become very much reduced so that nothing remains of the radial recurrent and radial sector. The disappearance of the cross-vein between $2A_1$ and $2A_2$ gives the pattern of the anal area a very different appearance from that of the other forms. Vein $3A_2$ is also obsolescent.

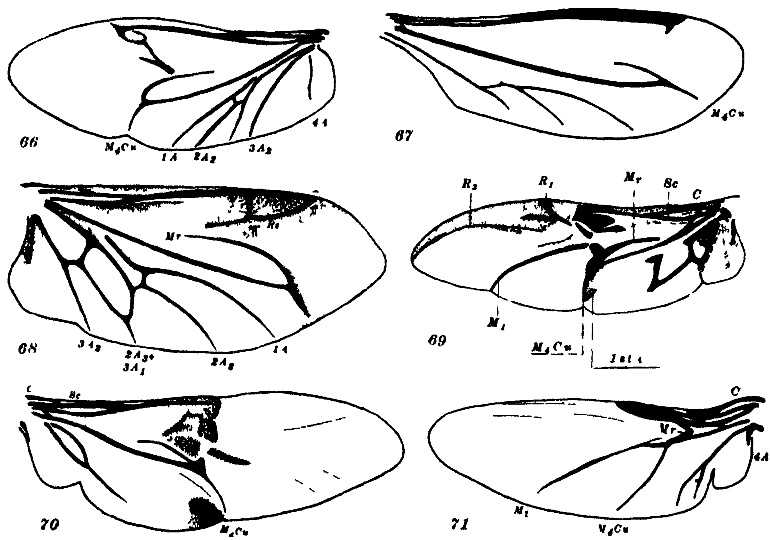


Fig. 66. *Mycetophagus flexuosus* Say. Fig. 67. *Hemipeplus marginipennis* Lec.
Fig. 68. *Erotylus diviiris* Lec. Fig. 69. *Hippodamia convergens* (Guer.).
Fig. 70. *Endomychus biguttatus* Say. Fig. 71. *Carpophilus pallipennis* (Say).

The radial recurrent in *Prostomis mandibularis* (Fig. 65) has disappeared while the radial sector and radio-medial cross-vein show signs of breaking up and disappearing. In spite of this condition of disappearance the radial region still bears resemblances to the radial region in Catogenus. The anal veins have become so distorted that Prostomis is isolated from the other Cucujidæ. Vein $3A_2$ has crossed over and joined $2A_3$. The cross-vein from $2A_2$ to vein $2A_1$ is also present, but vein 1A is absent.

Hemipeplus marginpennis (Fig. 67) has a venation radically different from that of the other genera of the family Cucujidæ. The anal lobe has completely disappeared and the anal veins are reduced to three in number. Their position is so altered that it is impossible to determine the veins with certainty.

The venation of *Telephanus velox* (Fig. 56), *Nausibius clavicornis* (Fig. 59) and *Oryzaephilus surinamensis* (L) (Fig. 54) all resemble

each other rather closely. The radial recurrent and radial sector are absent in these forms with a slight thickening remaining at the end of the radius which indicates that these forms are descended from forms like Brontes. Indications of the radio-medial cross-vein are also present. In the anal area three branches are separated from 2A. The vein $3A_2$ shows signs of disappearing in Telephanus and Nausibius while it is completely absent in Oryzaephilus. The anal lobe gradually becomes more definitely separated from the anal area, too. In Oryzaephilus the fourth anal vein is absent.

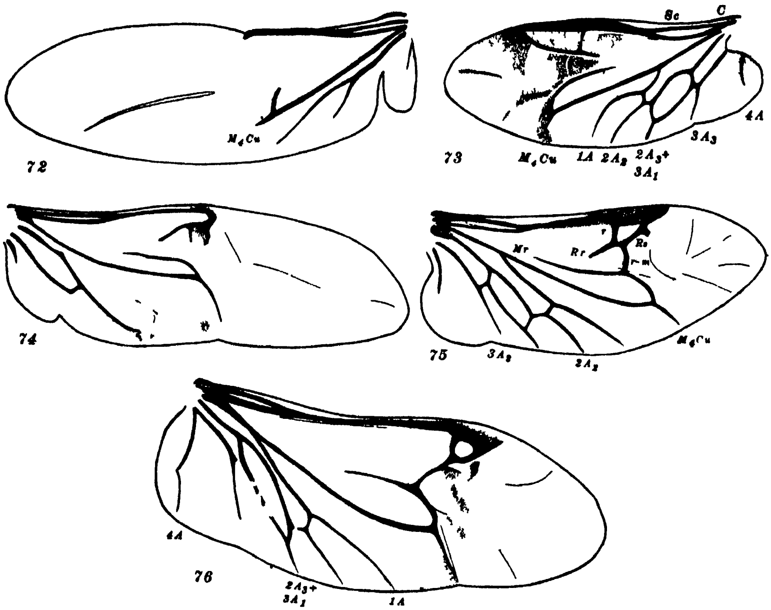


Fig. 72. *Phalachrus seriatus* Lec. Fig 73. *Agithus genuinatus* Lec.
Fig. 74. *Aphorista vittata* (Fabr.). Fig 75 *Triplax flavicollis* Lec.
Fig. 76. *Mycetophagus punctatus* Say.

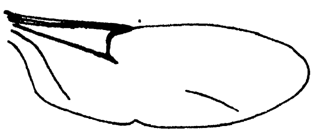
In *Silvanus bidentatus* (Fig 55) and *Cathartus opaculus* the veins of the anal area are very faintly indicated but the faint lines show these two genera to be related to the three genera just discussed. The shape of the anal lobe and the straight cubital vein are other points of similarity.

The five genera Telephanus, Nausibius, Oryzaephilus, Silvanus and Cathartus have a common type of venation and are distinct from the other members of the family Cucujidæ. The venation in this case indicates that these five genera may be separated as a distinct family on the following characters: Radius reduced to a single straight vein, with a small thickened area at the apex; Medial recurrent absent; $3A_2$ obsolescent; Anal lobe narrowly joined to the wing.

On the basis of wing venation *Laemophloeus liquidus* (Fig. 63) would be placed with Silvanus because of the very pronounced reduction of the venation and the distinct separation of the anal lobe from the remainder of the wing. It may be suggested here that since both Silvanus and Laemophloeus are small forms this reduction of venation may be due to the decrease in size. Then the similarity of venation in such form can not be used as a basis for determining relationships.

The venation of *Inopeplus reclusa* is also reduced to a minimum so that it resembles very closely the wing venation of Laemophloeus. The only difference between the two is that the medial-recurrent in Inopeplus is slightly longer than in Laemophloeus. This may be another case of convergence for the genitalia indicate that Laemophloeus and Inopeplus are not closely allied.

The venation of the family Nitidulidæ is represented by *Glistrochilus obtusus* (Fig. 61) for the veins of *Lobiopa setosa* and *Carpophilus pallipennis* vary only in slight details. The Nitidulidæ are peculiar in that



78

Fig. 77. *Monotoma producta* Lec.
Fig. 78. *Antherophagus ochraceus* Melsh.

the radial recurrent forms a deep loop toward the base of the wing which is unlike any of the other forms studied. The venation of the Histeridæ as illustrated by Forbes' figure of *Hister inequalis* agree with the Nitidulidæ in the loop-like form of the radial recurrent. Since this is the only detail in which the wings of the two families agree this must be considered as a convergence of characters. The presence of vein M_1 and the peculiar reduction of the anal veins is also characteristic of the Nitidulidæ.

In the Phalaridæ (Fig. 72) the wing is again characterized by a great reduction of the veins. The wing is long in proportion to the width which is rather remarkable in view of the lack of veins in the apical half of the wing. The members of this family are usually three millimeters or less in length. This small size of the beetle may again account for the extreme reduction of the wing veins.

The venation of the Cryptophagidæ as represented by *Antherophagus ochraceus* (Fig. 78) does not resemble any of the other families. The vein labelled M_1 is so labelled because it approximates the position of M_1 in *Carpophilus pallipennis* (Fig. 71) and because it is beyond the hinge fold. In none of the other forms does M_4 and Cu extend beyond the hinge fold. In *Cryptophagus croceus* this vein also appears to be a little nearer the costal border of the wing than in Antherophagus.

The presence of vein M_1 associates the Cryptophagidæ with the Nitidulidæ. In other respects, however, the venation resembles none of the other families.

The Monotomidæ (Fig. 77) have the venation reduced to such an extent that its affinities can not be determined. The radiomedial cross-vein is present as a short straight vein and shows no relationship to the Nitidulidæ.

The Endomychidæ are represented by *Endomychus bigutattus* (Fig. 70) and *Aphorista vittatus* (Fig. 74). In Aphorista the radial recurrent and radial sector are plainly visible with a short portion of the radiomedial cross-vein also present. The position of these veins is indicated in Endomychus by thickened areas. The anal veins are reduced to two veins at the base which converge to form a single vein toward the margin. The anal lobe is distinct, with a short fourth anal vein.

The venation of the Endomychidæ and Coccinellidæ is shown to be related when the venation of such forms as Scymnus is compared with the Endomychidæ, while in the more complex forms such as Hippodamia the relationship is not apparent. Another point which indicates the relationship of the two families is found in the folding of the wings. In both families the wings fold by a peculiar double fold at the hinge.

Hippodamia convergens (Fig. 69) is figured as typical of the Coccinellidæ The venation, as represented by the Coccinellidæ and Endomychridæ are divergent from that of the other families of the order, and serves only to emphasize their isolated position. The veins represented are costa, subcosta, radius, media, cubitus, and anals. The costa is a weak vein extends for a short distance along the costal border of the wing, then fuses with the subcosta. The subcosta is a concave vein near the costa. Radius is a large vein forming the principal articulation with the body. The branching of the radius has been greatly reduced. Caudad of the hinge, vein R_1 is represented by a thin line. Vein R_3 is so labelled according to Forbes for two reasons, "first, that the apex of wing in low holometabelous insects is to be sought in the neighborhood of R_3 and second, on the plain connection of the stub identified as R_4 and R_5 across to the stem of R_3 in such forms as Tetracha." The basal portion of the median has disappeared, leaving the medial recurrent unattached at the base. "The branches of the medius are designated as M_1 and M_4 because they are the extreme members of the complex group (polyphaga) as shown by Hydrosus." M_4 toward the apex swings over and joins the cubitus. There remains but one vein supplied by the cubital trachea. Near the margin of the wing a small portion of what is called first anal is still present. The other veins of the anal area have not been satisfactorily worked out.

SUMMARY OF VENATION.

To summarize the evidence from the venation: we have the Erotylidæ and Mycetophagidæ closely related and representing the most primitive type of venation.

In the family Cucujidæ the venation of Cucujus, Platisus, Catogenus, Brontes and Dendrophagus resemble each other very closely in the formation of the radial region. The anal veins are rather variable but this is not carried to such an extent that would require their separation as distinct families, particularly in the case of Catogenus. Prostomis shows an obsolescent condition of the radial region, which resembles that of Catogenus very closely. But the arrangement of the anal veins is such that it is difficult to state definitely the relationship. In the case of Laemophloeus it is impossible to determine definitely the relationship because of the extreme reduction of the venation. Hemipeplus shows a very marked reduction of the radial area and of the anal veins. Telephanus, Nausibius, and Oryzaephilus show the same type of venation, which with Silvanus and Cathartus, form a group apparently derived from a form like Brontes. This group is distinct enough to warrant family rank.

The Nitidulidæ possess a peculiar venation which is unrelated to any of the other forms studied.

In the Phalacridæ the venation is very reduced. In the anal area there are two veins left which slightly resemble the Nitidulid venation in this area.

The Cryptophagidæ according to the body characters and the genitalia should be placed close to the Erotylidæ, but the venation of the wings fail to show any relation to the other families.

The reduction of the venation of the Monotomidæ is so great that the relationship to other families is obscure.

The families Endomychidæ and Coccinellidæ are shown to be related both by the venation and the folding of the wings. This type of venation and folding is of such a distinct nature that the two families should be placed in a separate series.

CONCLUSIONS.

When a comparison of the evidence from the wing venation and the genitalia is made, the Mycetophagidæ are shown to be the most primitive of the families studied. Both the wing veins and the aedeagus indicate that the family is related to the Byrrhidæ and should be placed in the Byrrhoid series rather than with the Cucujoidea.

The genitalia, wing venation and body characters furnish no basis for a division of the Cucujidæ into the four families as suggested by Böving. All of the evidence does indicate, however, that the family Silvanidæ as proposed by Böving may be accepted. The genus Telephanus is closely related to Brontes, thus the Silvanidæ are related to the Cucujidæ.

Handlirsch in arranging the fossil Coleoptera suggests that the Cucujidæ arose from a hypothetical Protophytophaga as early as the Upper Triasic, while the other families usually included in the series Clavicornia arose during the Jurassic and Cretaceous. He separates the Cucujidæ as a distinct series. The fact that the wing venation of the Cucujidæ and Silvanidæ is not related to other families supports Handlirsch's view. The aedoeagus also furnished eviden ce which indicate that the Cucujidæ and Silvanidæ should be recognized as independent. The aedoeagus of the Cucujidæ ranges from a very simple type in Hemipeplus to a very complex type in Catogenus. This diversity of structure leads to the conclusion that the family is a very old one from which many intermediate forms have disappeared. The Cucujidæ and Silvanidæ are separated from the Mycetophagidæ by the fact that the tegmen forms a complete ring around the median lobe, and are distinguished from the other families studied by the fact that the tegmen is ventrad of the aedeagus. Such considerations, I believe, justify separating the Cucujidæ and Silvanidæ from the other families studied. The series Cucujoidea would then include only the families Silvanidæ and Cucujidæ.

According to the genitalia the Nitidulidæ, Monotomidæ and Phalacridæ constitute a homogeneous group having the tegmen redued to a single large sclerite on the dorsal aspect of the aedeagus. On the basis of the genitalia the Phalacridæ should be placed near the Nitidulidæ instead of between the Endomychidæ and Coccinellidæ, which is the usual arrangement. Since the Silvanidæ and Cucujidæ are considered as a distinct series the three families Nitidulidæ, Monotomidæ, and Phalacridæ will constitute a new series for which I propose the name Nitiduloidea. The wing venation of this series is so reduced that it is of little assistance in determining the relationship of these families.

The Erotylidæ, Cryptophagidæ, Endomychidæ, and Coccinellidæ are placed together to form another series to which I

give the name Erotyloidea. This group is characterized by having the tegmen composed of a basal piece enclosing the median lobe, and the lateral lobes attached to the sides or apex of the basal piece. The aedeagus also rests on its side when retracted into the abdomen and is arranged so that it turns through an angle of ninety degrees when extruded. The wing venation of the Erotylidæ resembles that of the Mycetophagidæ more closely than that of either of the other three families, but the evidence from the genitalia indicates that the Erotylidæ should be placed with the Crytophagidæ, Endomychidæ, and Coccinellidæ. The venation of the Endomychidæ and Coccinellidæ is very similar. The method of folding the wings in these last two families is also exactly the same.

ACKNOWLEDGMENTS.

For the loan of material I am indebted to Professor Nathan Banks of the Museum of Comparative Zoology, who generously allowed me to take duplicates from the Museum collection for dissection. Mr. A. J. Mutchler of the American Museum also loaned specimens of Cathartus and Silvanus for comparison. The work was carried on under the direction of Professor W. M. Wheeler and Professor C. T. Brues, and to both I am greatly indebted for valuable suggestions and helpful advice.

BIBLIOGRAPHY.

Berlese, A. 1909. Gli Insetti. Societa Editrice Libraria, Milano.

Boving, A. G., 1921. The Larvae and Pupae of the Social Beetles Coccidotropus socialis Schwarz and Barber and Eunausibius wheeleri Schwarz and Barber With Remarks on the Taxonomy of the Family Cucujidae. Zoologica III, 7, pp. 197-213.

Burmeister, H., 1842. Handbuch der Entomologie.

Chlodkowsky, N., 1891. Die Embryonalentwicklung von Phyllodroma (Blatta) germanica. Mem. de l'Acad. Imp. des Sciences de St. Petersb. 7 ses tom. 38, No. 5.

Dewitz, H., 1875. Ueber Bau und Entwicklung des Stachels und der Legescheide einiger Hymenopteren und der grunen Heuschrecke. Zeitsch. f. wiss. Zool. 25 Bd.

Forbes, W. T. M., 1922. The Wing-Venation of the Coleoptera. Ann. Soc. Ent. of Amer., XV, pp. 328-345.

Ganglbauer, L., 1899. Kafer von Mitteleuropa.

1903. Systematisch-Koleopterologische Studien. Munch. Kol. Zeitschr. I, pp. 271-319.

Heymons, R., 1899. Die morphologische Bau des Insekten-abdomens. Zool. Centralb. 6. pp. 537-556.

Huxley, T. H., 1877. A Manual of the Anatomy of the Invertebrate Animals. London.

Kobbe, H. J., 1893. Einfuhrung in die Kentnnis der Insekten. Berlin.
1901. Verglelchend-morphologische Untersuchen an Coleopteren nebst Grundlagen zu einem System und zur sustematick derselben. Arch. F. Naturg. Beiheft.
1908. Mein System der Coleopteren. Zeitschr. fur Wiss. Insektenbiologie, IV, pp. 116-400.
Korschelt, E. and **Heider, K.**, 1892. Lehrbuch der vergleichenden Entwicklungsgeschichte der wirbellosen Thiere. Spez.-Theil. 2 Heft.
Krapelin, C., 1873. Untersuchungen uber den Bau, Mechanismus und Entwicklungsgeschichte des Stachels der biencnartigen Thiere. Zeitschr. f. wiss. Zool. 23 Bd.
Kowalevesky, A., 1872. (Note on Uljanin's researches on the sting of the bee.). Sitz. Ber. d. Zool. Abth. d. 3 Versamml. Naturf. in Kiew. Zeitschr. f. wiss. Zool. 22 Bd.
Kuhne, O., 1915. Der Trachienverlauf im Flugel der Koleopterennymphe. Zeit. f. wiss. Zool. 112 Bd. pp. 691-718.
Lameere, A., 1900. Notes pour la classification des Coleopteres. Ann. Soc. Ent. Belg. XLIV, pp. 55.
Leng, C. W., 1920. Catalogue of the Coleoptera of N. A., North of Mexico. Mount Vernon, N. Y.
Martinov, A. B., 1925. Uber zwei Grundtypen der Flügel bei den Insekten und ihre Evolution. Zeit. für Morphologie und Okologie der Tiere. pp. 465-501.
Muir, F., 1915. Notes on the Ontogeny of the Genital tube in Coleoptera. Psyche 22, pp. 147-152.
✓ 1918. Development and morphology of Male Genitalia. Tr. Ent. Soc. Lond. pp. 223-229.
Newell, A. G., 1918. The Comparative Morphology of the Genitalia of Insects. An. Ent. Soc. Amer. XI, 2 pp. 109-142.
d'Orchymont, 1921. Apercu de la nervation alaire des Coleopteres. Ann. Soc. Ent. Belg. 61, 256-278.
Peytoureau, A., 1895. Remarques sur l'organization et l'anatomie comparee des derniers segments du corps des Lepidoptera, Coleoptera, et Hemiptera. Review Biologique du Nord de la France, 7 Annee, pp. 29-131.
Schwartz, O., 1895. Entgegnung auf Herrn Verhoeff's Erwiderung über den Copulatiomsapparat männlichen Coleoptera. D. E. Z., 27-36.
Sharp, D. and **Muir, F.**, 1912. The Comparative Anatomy of the Male Genital Tube in Coleoptera. Tr. Ent. Soc. Lond. pp. 477-642.
Tanner, V. M., 1927. A Preliminary Study of the Genitalia of the Female Coleoptera. Tr. Ent. Soc. Amer. LIII, pp. 5-50.
Verhoeff, C., 1893a. Vergleichende Untersuchungen uber die Abdominalsegmente und die Copulationsorgane der mannlichen Coleoptera, ein Beitrag zur Kentnnis der naturlichen Verwandtschaft derselben. D. E. Z. 37, pp. 113-170.
1893b. Untersuchen uber die abdominalsegmente, insbedondere die Legeapparate der weiblichen Coleopter, ein Beitrag zur Phylogenie derselben. D. E. Z. 37, pp. 209-260.
Verhoeff, C., 1895a. Beitrage zur vergleichenden Morphologie des Abdomens der Coccinelliden und uber die Hinterleibsmuskulatur von Coccinella zugleich ein Versuch die Coccinelliden anatomisch zu begrunden und naturlich zu gruppiren. Arch. Naturg. LXI, 1-80.
1895b. Vergleichend-morphologische Untersuchen uber das Abdomen der Endomychiden, Erotyliden, und Languriiden. T. C., 213-287.
1896. Zur Morphologie der Segmentanhanger bei Inskten und Myriapoden Zool. Anz. XIX, pp. 378-383 and 385-388.
Weise, J. Entgegnung auf Verhoeff's Erwiderung. D. E. Z. pp. 19-27.
Weisemann, A., 1866. Die Metamorphose der Corethia pulmicornis, ein weiterer Beitrag zur Entwicklungsgeschichte der Insekten. Zeitschr. f. wiss. Zool. 16 Bd.
Wheeler, W. M., 1889. The Embryology of Blatta Germanica and Doryphora decemlineata. J. Morph. 3 pp. 291-386.
1893. A Contribution to Insect Embryology. J. Morph. 8, pp. 1-60.

CONTRIBUTIONS TO THE LIFE HISTORY OF THE ICERYINE COCCIDS, WITH SPECIAL REFERENCE TO PARTHENOGENESIS AND HERMAPHRODITISM.

SALLY HUGHES-SCHRADER,*
Bryn Mawr College, Bryn Mawr, Pa

CONTENTS

INTRODUCTION.

The coccid tribe Iceryini as recently defined by Morrison ('28, '30) comprises the genus Icerya and five other genera closely allied to it. Of this group the life cycle of only *Icerya purchasi*, the cottony cushion scale, is at all adequately known. This species presents so many unique features, especially relative to its reproductive processes, that any contributions to our knowledge of nearly related species holds an especial interest. The present study presents new data on four other members of this group—data derived from field study, from the cytological investigation of material preserved in the field, and from breeding experiments, made during two extended trips in Central America in the years 1928 and 1929. The species

*Sarah Berliner Research Fellow, 1929.

studied are *Icerya montserratensis* Riley and Howard and *Icerya littoralis* Cockerell, two forms, which, with *Icerya purchasi* Maskell, represent three different sections of the genus Icerya, *Crypticerya rosæ* Riley and Howard, and *Echinicerya anomola* Morrison, a new genus and species discovered during my 1928 trip in Guatemala and recently described by Dr. H. Morrison of the United States Bureau of Entomology. To Dr. Morrison I am also indebted for the identification of all the other types herein reported. Grateful acknowledgment is also made to the donor of the Sarah Berliner Research Fellowship, and to the American Association of University Women awarding it, whose support made the field work of 1929 possible. The field work of 1928 was done in collaboration with Professor Franz Schrader of Bryn Mawr College.

A preliminary review of the life cycle and reproductive processes of *Icerya purchasi* will first be presented. For, although the general features of the life history of this species have been known since the pioneer studies of Riley and Howard ('86, '90), it is only recently that a correct interpretation of its reproductive processes has been reached. The present review is intended therefore to bring together in one report the somewhat scattered material now available on this type, and thus to facilitate comparisons with the other Iceryines studied.

Icerya purchasi Maskell.

DISTRIBUTION AND HOSTS.

Morrison gives the present occurrence of *Icerya purchasi* as world wide, Australia having been the probable center of its distribution. Aside from greenhouse infections in many cities of the United States, I have encountered it living outdoors in many localities in California, in Louisiana, and in Guatemala, Central America. In food habit *Icerya purchasi* is truly polyphagous. The various species of Acacia, Mimosa, citrous trees, and roses seem especially favorable hosts. But inasmuch as Ptospormum, cypress, pine, grasses, elm, ivy, oxalis, and palms have all been observed as hosts, it is clear that there is no obligatory relation between the insect and any certain group of host plants.

LIFE CYCLE.

The general structure and appearance of the different instars of *Icerya purchasi* are too familiar to need review here: The life cycle occupies, according to Kuwana ('22b), approximately four months under favorable conditions in Japan. Thus three generations are possible there annually. Leonardi ('20) reports three generations annually to be characteristic for the species in Italy; and under greenhouse conditions in Pennsylvania I find the same to hold true. Unfavorable environmental conditions may increase the duration of each or all instars, so that as few as one generation may be obtained in a given year. Kuwana gives the average life cycle as follows for females:

Incubation period	21 to 27 days
First instar	14 to 21 days
Second instar	14 to 21 days
Third instar	21 to 50 days

I can add that the fourth or adult stage in the female usually comprises from two to three months. For males the incubation and first and second instar periods are the same as in the females. Third instar males, however, immediately after the second molt, undergo a short period of restless wandering and then hide away in dead leaves or bark crevices and secrete the "cocoon" of loose wax in which the third and fourth instars are passed. This cocoon period comprises 17 to 21 days. The adult male or fifth instar has a maximum life of eight days after emergence from the cocoon, I can substantiate these data of Kuwana's in every respect from my own breeding experiments on this species.

The mating habits of *Icerya purchasi* have been described in detail by Shinji ('17) and myself ('25). Copulation occurs in nature usually during the late afternoon. The males evince a weak mating instinct as compared with the females. The latter react at once to the near approach of the males by raising the posterior tip of the abdomen. When copulation occurs the male mounts the up-tilted body of the female and clings to its posterior margin. The abdomen of the male is then bent under that of the female, and the penis inserted into the genital aperture of the female. The female retains the position with abdomen upturned during copulation thus holding the male up from the surface of the host plant. Copulation lasts from two

to five minutes. Females will mate frequently and with many different males; the males rarely mate more than once, and it is not unusual for a male entirely to ignore the presence of females even though the latter may be reacting vigorously at the time.

The females are capable of copulation immediately after the third molt, and for a variable number of days thereafter, the period being terminated by the growth of the wax egg-sac which soon covers the genital aperture. All fourth instar females whether fertilized by males or not produce these characteristic egg-sacs. Eggs are deposited continuously during a period of about two weeks, the first young hatching in three to four weeks after the beginning of egg-sac formation. Due to the very long adult life of the females the generations of *I. purchasi* are seen to overlap; but counting from the time of the egg laying in one generation to the egg laying in the next, it will be seen that approximately ten to fourteen weeks are required to complete one cycle.

There are several possible causes for the wide variation in duration of the different periods of the life cycle as computed above. Any instar may be lengthened by various unfavorable environmental conditions such as a sudden drop in temperature, the cessation of active growth of the host plant, or too moist an atmosphere. The last factor favors the growth of molds in the sweet excreta of the insects. Some of these molds actually infect the bodies of the insects themselves and, although seldom fatal, slow up development decidedly. Again the incubation period, as Kuwana terms the time between egg laying and hatching, is extremely variable due to the fact, common among coccids, that the eggs are retained in the body of the mother until widely different degrees of development are attained.

SEX RATIO, PARTHENOGENESIS, AND HERMAPHRODITISM

All observers of *I. purchasi* agree in reporting a very unbalanced sex ratio, with the females preponderating largely over the males. This scarcity of males, together with his embryological studies on the species, early led Pierantoni ('10) to conclude that parthenogenesis was the usual mode of reproduction. He therefore isolated young female nymphs from males and discovered that indeed egg sac formation, egg laying, and the production of normal young occurred in the

complete absence of males. Later Kuwana ('22) also reported parthenogenesis for this species, after having raised several generations in the complete absence of males. That the rare males do mate with the females in nature has been repeatedly observed as noted above (Martelli (Pierantoni '10), Shinji ('17), Kuwana ('22), and Hughes-Schrader ('25)). Altogether the above evidence would ordinarily be considered an adequate demonstration of the occurrence of a facultative parthenogenesis. In this case however the situation was further complicated by the interesting observation of Pierantoni ('14a) that certain of the nymphs showed traces of hermaphroditism in their gonad structure. Pierantoni believed this hermaphroditic phase to be a transient one and the hermaphroditic nymphs to transform into normal males.

My own work (Hughes-Schrader '25, '26, '27) has demonstrated that all of the so-called females of *Icerya purchasi* are in reality hermaphrodites capable of the self-fertilization of their own eggs by their own sperm. Copulation may indeed occur between these hermaphrodites and the occasional males, but it is in no wise necessary for reproduction. Cytological study shows that the hermaphrodites are always diploid in chromosome constitution while the males are haploid. The diploid chromosome number is four, and the haploid two; in both sexes the cytological conditions are exceptionally clear and convincing. The hermaphroditic gonad is basically an ovary. During development the right and left gonads meet and fuse anteriorly dorsal to the gut thus forming a horseshoe shaped structure whose posterior ends terminate in short ducts. The fusion of these ducts posteriorly forms a heavy walled glandular vagina which leads to the external genital aperture. At the point of junction of the ducts there may occur a small thin walled blind diverticulum, the spermatheca, as described by Johnston ('12); but this may be entirely absent as stated in my 1925 study. Since that time I also have found it present in certain specimens, and believe it to be of rather general although variable occurrence. In the majority of coccids the ovaries are hollow structures with the eggs forming in pouches or ovarioles from their walls. In *Icerya purchasi* however the hermaphroditic gonad is solid during the early instars. In the first instar certain of the centrally lying cells become reduced to the haploid condition, and these

haploid cells, proliferating rapidly, come to form a solid central core in the gonad. The outer cells remain diploid and from them the ovarioles with their oocytes and nurse cells, the follicular and interstitial tissue are all derived. The haploid cells give rise to sperm. As the sperm mature they become twisted into tight bundles; the bundles are coiled and come to lie freely in the central cavity of the gonad. The gonad is thus actually hollowed out by the process of sperm formation. From the outer walls of the gonad meanwhile normal ovarioles are developing in which the eggs come to maturity. All eggs undergo two normal maturation divisions, in which the chromosomes are reduced to the haploid condition. If these eggs are fertilized by sperm, diploid embryos are produced which always give rise to hermaphrodites. If the eggs remain unfertilized, they develop parthenogenetically into haploid males. Fertilization of the eggs of the hermaphrodite by its own sperm has been demonstrated cytologically in a large series of hermaphrodites which were held in complete isolation from males.

Since the hermaphrodite produces ripe sperm in large numbers before the period when copulation with a male is possible, one cannot determine with certainty whether the sperm of the males are also potent. Copulation does not affect the parthenogenetic production of males; extended breeding experiments have shown that males are produced in varying numbers indifferently by both hermaphrodites which have mated with males and those which have been completely isolated from males. Thus from 31 hermaphrodites which had mated with males 2,548 hermaphrodites and 39 males were produced; while 10 hermaphrodites isolated from males gave rise to 1,616 hermaphrodites and 5 males.

There is no evidence that this condition,—of functional hermaphroditism coupled with facultative parthenogenesis of haploid males—is restricted to an isolated strain or sub-species of *Icerya purchasi*. On the contrary, I have examined material from Italy, from Boston, Massachusetts, New York City, New York, Philadelphia, Pennsylvania, Berkeley, California, and from Antigua, Guatemala, and in every case have found the same conditions. It is certainly probable that this condition is characteristic for the species as a whole. With reference to this point an examination of *Icerya purchasi* as it occurs in Australia, its supposedly original center of distribution, would be of extreme interest.

The general anatomy of the hermaphrodites, their close correspondence in structure and habits with the true females of other coccids, together with their retention of the mating instinct of females, all indicate that the *I. purchasi* hermaphrodites are modified females. Indeed the very existence of normal males is evidence of the primitively bisexual condition of the species. That the hermaphrodites are homogametic for sex as are the females of other coccids (see Schrader's work on Gossyparia and many species of Pseudococcus and Thomsen's studies on several Lecanium species)—is shown by the fact that all their eggs when self-fertilized give rise again to the hermaphrodite type. The establishment of functional hermaphroditism as the regular and successful mode of reproduction in *I. purchasi*, may thus be regarded as definitely a derived and not a primitive character. The facultative parthenogenetic production of haploid males on the other hand may be a primitive character surviving, or, as the small and variable number of males produced may indicate, dying out in consequence of the establishment of the hermaphroditic habit; or, it may represent another secondary development paralleling that of hermaphroditism. Such considerations as these, together with the further questions whether these unique sexual and reproductive conditions represent an isolated development in a single species or are typical for a larger group of forms,—whether any transitional or related phenomena may exist in related species,—gave the point of departure for the following studies on closely related forms.

Icerya montserratensis Riley and Howard.

DISTRIBUTION AND HOSTS.

Icerya montserratensis has been reported from the West Indies and from Mexico, on a wide range of host plants including unidentified species of Chrysophyllum, Clusia, Acacia, orange, banana, avocado, and palm. My collections were made at Belize, British Honduras, on various cultivated roses and palms, and at Stann Creek, British Honduras, on grapefruit trees. Although so unrestricted in choice of host plant, the insects thrive better on certain forms than on others. In my experience rose offers the best medium, with palms second. Reduced size and very slow development characterize broods grown on any of the citrous fruit trees.

As in *Icerya purchasi* the young nymphs attach themselves to the under side of the leaves of the host plant, sinking their proboscides into the veins of the leaves. Older nymphs and adults attach themselves to the twigs and smaller branches. Recognition of *I. montserratensis* in the field is easy, due to the large fluted egg sac of the adult female which turns up at the distal end instead of downward as in *I. purchasi*. The marginal wax tufts on each side of the anus are prolonged into graceful and often curling strands sometimes reaching a length twice that of the body of the female. These strands hanging posteriorly and ventrally over the egg-sac form a striking character for naked-eye recognition. The anterior median wax tuft is also tremendously developed (about half the length of the body) and projects forward stiffly.

NUMBER OF GENERATIONS ANNUALLY.

During the dry season from three to four months are required for the completion of a single generation. Since all instars are present on the host plants from January until May, it is probable that breeding goes on more or less continuously throughout the year. If this is the case three generations a year are possible as in *I. purchasi*. Lowering of the temperature will however retard development greatly in all instars, and it is quite possible that the number of generations annually varies from one to a maximum of three depending on weather and food conditions.

DURATION OF THE SUCCESSIVE INSTARS.

Under favorable growing conditions the first larval instar in both sexes occupies from 19 to 25 days; the second instar from 17 to 24 days in the case of males, and 19 to 24 days in the case of females. Immediately after the second molt the behavior of the two sexes differs. Male larvæ of the third instar become restless and migrate from the host plant seeking a dark place in which to spin their cocoons. They may be easily distinguished from the females at this time by their longer slenderer abdomen and the almost complete absence of wax. One or two days may be spent in active wandering back and forth, after which the male larvæ settle down in the loose dry surface earth or in dead leaves and bark crevices, and secrete their cocoons of very loose and fluffy wax. The whole

third and fourth instars are spent in the cocoon—an average interval of 26 days elapsing between the second molt and the emergence of the adult males. The time of the occurrence of the third and fourth molts was determined in a few cases only. Cocoons opened to obtain cytological material showed that the third instar has an average duration of 9 to 10 days. Similarly, in a few cocoons opened on the 23rd day of the cocoon period, one male was found which had already made its last molt. It is probable therefore that from one to several days of the cocoon period belong to the adult stage. After emerging from their cocoons the adult males live for 3 to 8 days.

Female nymphs continue to feed quietly on the host plant during the third and fourth instars. In four individuals timed the duration of the third instar was from 20 to 29 days. Immediately after the third and, for the females, the final molt, the females are ready for fertilization. The long duration of the third instar in the female as compared with male nymphs quite equalizes the fact that the females have one less instar than the males, and brings the time of sexual maturity in the two sexes simultaneously. Thus the total time required for the larvæ to reach sexual maturity from the time of the hatching of the eggs is 57 to 78 days in the case of males and 56 to 78 days in the case of females. The adult life (fourth instar) of the female, whether fertilized or not, is very much longer than that of the male—always comprising one month and often six to nine weeks.

MATING, EGG-SAC FORMATION, AND DEPOSITION OF EGGS.

As in *I. purchasi* the mating instinct is much stronger in females than in males. Practically all females for two or five days after their third molt will react by lifting the tip of the abdomen to the presence of males, if the latter come within a distance of half an inch or less. The males on the other hand are very capricious—occasionally reacting immediately to the presence of females of suitable age, but as often showing no reaction whatever and even climbing over the upraised bodies of the females to attain a sheltered position on the under side of a leaf. When a mating does occur there is no preliminary courtship other than an occasional stroking of the body of the female with a foreleg of the male. Copulation occurs as in *I. purchasi;* the male clings to the posterior tip of the abdomen

of the female and slips his abdomen under hers to insert the penis into the genital aperture. Due to the small size of the male he is usually held up free from the host plant by the up-raised abdomen of the female during the copulation, which lasts from three to seven and a half minutes. A single female often mates more than once and with many males. A single male seldom mates more than once in a given day—although it is probably unfair to judge their behavior in nature from that of specimens kept in vials and only liberated for short periods for experimental purposes, as were those on which these observations are based. One male used in the breeding experiments described below gave five matings on consecutive days but it was more usual to obtain none, one or two from each specimen.

Within one or two days after copulation the ventral side of the abdomen of the female becomes covered with wax, thus preventing further mating. However the females will still to the approach of males for many days after this time, react although the males invariably ignore such advances. The characteristic egg-sac, long, fluted, gradually turning up at the posterior end, begins to form within a few days after fertilization, and slowly increases in size during the period of egg laying. The first eggs are deposited as soon as the first section of the egg-sac is complete, often as soon as four or five days after fertilization, and eggs continue to be deposited thereafter for many days. From the time of fertilization to the emergence of the first young from the hatching eggs 33 to 35 days elapse. As was pointed out for *I. purchasi* this period does not correspond necessarily to the whole embryonic period since the eggs are at very different stages of development when they are deposited. One entire life cycle, from the hatching of the eggs in one generation to the hatching of the eggs of the next generation, is seen to occupy from 90 to 113 days. These records are based on several broods growing on rose trees in the dry season and probably represent maximum speed of development. Some idea of the variation in the length of the life cycle under less favorable conditions may be gained from the following observation. From one brood whose total developmental period on rose was just three months, some young were transferred early in their first instar to a grapefruit tree. The host plant was over-crowded, molds developed in the excreta of the insects, and in general the conditions were

very unfavorable. These nymphs were still in their second instar when that part of the parental brood raised on the rose tree had reached the adult stage. This would indicate a possible retardation of the developmental period to double that required under favorable circumstances.

SEX RATIO, PARTHENOGENESIS, AND HERMAPHRODITISM.

Virgin females, kept in isolation from males, behave at first quite as do those which have mated with males. The egg-sac, although its formation is delayed until the fifth to seventh day after the final molt of the female, eventually attains as large a size as in fertilized females. The number of eggs laid is approximately the same. Thus far conditions parallel those in *I. purchasi* closely. In marked contrast to *I. purchasi*, however, the young produced by unfertilized females of *I. montserratensis* are always male in sex. This conclusion is based on breeding experiments in which virgin females were kept under gauze bags and thus isolated from males. Records of the separate broods were not kept, other than to check up daily during the crucial instars for the possible appearance of females among the offspring. Some 200 males and not one female were produced by three such isolated females. Broods from fertilized females, on the other hand, always comprised both males and females. Exact records were not kept of the number and sex of the offspring of each fertilized female, owing to inadequate facilities for growing and isolating the broods, but a mass culture from several fertilized females on one rose tree produced some 200 young, among which some ninety males were recorded. Meager as they are, these breeding experiments indicate fairly clearly that fertilization is necessary for the production of female offspring, while males may be produced from virgin females. Such experimental breeding is however inadequate for an analysis of the reproductive processes involved, since it provides no distinction between the effects of parthenogenesis and hermaphroditism. Accordingly a cytological study was made of both fertilized and non-fertilized females and of the eggs of each type in all stages of their development. A detailed account of the purely cytological features of gametogenesis, fertilization, and development will be published elsewhere. It will suffice here to summarize only those results bearing directly on the life history.

In the first place there is no trace of hermaphroditism in any instar of either sex. The gonad of the female is a typical ovary. In general form it corresponds to the hermaphroditic gonad as described for *Icerya purchasi.* The right and left ovaries fuse anteriorly dorsal to the gut thus giving the organ a circular shape. This fusion occurs early in the second instar. Posteriorly each ovary terminates in a duct which unites with its fellow from the other ovary to form a thick walled glandular vagina. At the point of junction of the two ducts a small and very delicate thin walled spermatheca has its origin. As in most coccids the cavities of vagina and ducts are continuous with the central cavity of the ovary. The eggs are produced in typical ovarioles on the wall of the ovary and pass into its central cavity when mature. The ovaries are hollow from a very early period in their development and there is never a trace of the development of spermatogenous tissue in them such as is found in *I. purchasi.* The constant presence of a spermatheca, a character subject to considerable individual variation in *I. purchasi,* and the comparatively greater length of the sterile ducts connecting ovaries and vagina, further distinguish the *I. monserratensis* from the *I. purchasi* gonad. The anterior fusion of the right and left gonads is shown in *montserratensis* in common with all the Margarodidæ thus far examined; it may well prove to be a constant anatomical character for the whole family. Schrader ('30) has recently described this same general type of ovary as being characteristic for *Protortonia primitiva.* In Protortonia, however, the ducts are even shorter than in *I. purchasi* and the egg bearing region of the ovary correspondingly longer. The spermatheca is also relatively better developed than in any of the Iceryines studied.

The diploid chromosome number in *I. montserratensis* is four All eggs undergo two perfectly normal maturation divisions by which the chromosome number is reduced from four to two. If the eggs are fertilized and the diploid condition thus restored they develop into females. All unfertilized eggs develop into males which thus come to be characterized by the haploid chromosome number.

These findings confirm and explain the results of the breeding experiments. Isolated females naturally produce nothing but males since all their eggs undergo reduction and develop without fertilization or other means of restoring the diploid chromosome

condition as haploid male individuals. Fertilized females, on the other hand, produce mixed broods, those eggs which are fertilized by sperm developing into females and those which escape fertilization developing parthenogenetically into males. In the light of this cytological mechanism the number of males produced by fertilized females seems surprisingly high. A discussion of the possible causes for this phenomenon will be reserved until the section dealing with *Icerya littoralis*, since my breeding data for the latter species are more complete relative to this particular point.

Icerya littoralis Cockerell.

DISTRIBUTION AND HOSTS.

Icerya littoralis was collected and studied in the vicinity of Salamà, Baja Vera Pas, Guatemala, during the spring of 1929. The usual host plant was a common species of acacia, locally called subin, although other species of acacia, palms, and even certain grasses near a heavy infection, were also observed to be occasional hosts. Breeding probably continues more or less regularly throughout the year, since all stages from first instars to adults were present on the host plants at all times during February, March, April, and May. As in *I. monserratensis*, a dry season brood may be completed in from three to four months, thus making three generations a year at least theoretically possible.

In the field, *I. littoralis* has a very characteristic appearance. It resembles *I. purchasi* closely in body form, and in the down turned fluted egg-sac, but may be readily distinguished in naked-eye examination by its smaller size, the absence of the black hairs of *purchasi*, and by the color of the skin which is a bright rose red in contrast to the brown red of *purchasi*. The adult female is closely covered with wax dorsally; the marginal wax tufts are very short in front and increase in size by uniform degrees from anterior to posterior, thus making a fringe of wax tufts which hang down over the completed egg-sac. The longest of these tufts is seldom as long as the body of the female; this, and their even gradation in length, make confusion with *I. montserratensis* impossible.

LIFE CYCLE.

In general habits this species approximates *I. monserratensis* so closely that only a brief summary of my notes relative to its life cycle will be submitted. The duration of the different instars is as follows. In the case of male nymphs, the first instar occupies on an average 20 days, the second 15, and the third and fourth together or cocoon period, 21 to 25 days; giving a total of 57 to 60 days from hatching to sexual maturity. Female larvæ spend 20 to 25 days in the first instar, 16 to 19 in the second, and 22 to 30 in the third—a total of 58 to 74 days from hatching to sexual maturity.

Females are capable of fertilization immediately after the third molt and for the five or six days immediately ensuing. Mating habits are identical with those of *I. montserratensis*. The duration of copulation is markedly shorter, varying from two to four minutes in the sixteen cases observed. Both males and females may copulate more than once either with the same or different individuals. One male was seen to mate three times, on successive days—and one female to mate four times in rapid succession with four different males. The mating period of the female is terminated by the growth of the egg-sac which soon covers the genital aperture.

The secretion of the egg-sac is begun on the fifth to seventh day of the fourth instar irrespective of whether the female has been fertilized or not. The first eggs are deposited as soon as the first short section of the sac is completed. Continued slow deposition of eggs and the gradual posterior extension of the egg-sac go on for two to three weeks. The first larvæ hatch in from 31 to 38 days after the egg-sac has been started, and first instar larvæ continue to emerge thereafter for two or three weeks more. Summating these periods it will be seen that the duration of the life cycle, from the hatching of the eggs of one generation to the hatching of the eggs of the next, is 94 to 119 days. Again it should be emphasized that these figures apply to dry season broods under favorable conditions of growth.

SEX RATIO, PARTHENOGENESIS, AND HERMAPHRODITISM.

The sex ratio in *I. littoralis*, determined from a random collection of larvæ preserved for cytological study, was 30 males to 14 females, a ratio sufficiently one-sided to suggest

unusual reproductive behavior. Breeding experiments demonstrated conditions paralleling those in *I. montserratensis.* Virgin females form egg-sacs and lay eggs, as do females fertilized by males, but all eggs from virgin females give rise to male offspring exclusively. One such virgin female, reared in careful isolation from males, produced 24 males and no females. (This brood was greatly reduced by predacious mites before sex determination was possible.) Two other virgin females, whose offspring were not separated upon the host plant, produced 102 offspring, all of which were males. In no case did any virgin female give rise to female offspring. Fertilized females, on the other hand, produce both male and female young. Three females, each of which had copulated at least once, produced the following broods: 29 males to 51 females, 23 males to 20 females, and 43 males to 49 females. All of these broods are smaller than is normal in nature due to the difficulties in rearing complete broods on small plants under observation. The larvæ reared represent a random selection from the eggs in a given egg sac.

As was suggested for *I montserratensis* the percentage of eggs that fail of fertilization in females that are known to have mated with potent males is surprisingly large. In the breeding experiments listed above the males are seen to comprise 44% of the brood of fertilized females. One factor in keeping the number of males high may well be insufficiency of sperm. It seems quite probable that the number of sperm received by the female at a single mating should be insufficient for the fertilization of the large number of eggs often produced. The conditions in *Icerya purchasi* lend support to this hypothesis. In *I. purchasi* sperm are produced by the hermaphrodites in tremendous numbers—(at the end of the male phase the ducts of the hermaphroditic organ are filled with sperm and sperm bundles from anterior to posterior end); and the number of males produced is correspondingly small. A second possibility is that some eggs may start their parthenogenetic development before copulation. I have had no opportunity to check this with precision cytologically. In the few females examined cytologically just before egg-sac formation no developing eggs or embryos were encountered, but I consider the evidence insufficient to eliminate the possibility that comparatively late copulation may be an occasional factor making toward a high

percentage of male progeny. The very small number of males produced by I. purchasi may be cited in indirect support of this suggestion also. There is no possibility in this case that the eggs start development before the arrival of the sperm since the hermaphroditic gonad is markedly protandrous and the sperm mature long before the eggs. It is clear that other factors than those just suggested must be operative in the case of *I. purchasi* to account for the production of any males at all by that species. It has been suggested (Schrader and Hughes-Schrader '26) that a late opening of the peduncular ducts connecting the egg follicle or ovariole with the main duct of the gonad might act as a bar to fertilization until after parthenogenetic development was under way. Such undetermined factors may well operate also in the cases of *I. montserratensis* and *I. littoralis*. Some further analysis of the factors involved in this question could be obtained by breeding experiments designed to determine the effect of the age of the female, and of repeated matings, on the sex ratio.

Cytological conditions in *I. littoralis* also parallel those of *I. montserratensis* with surprising closeness. There is never any trace of hermaphroditism in any instar. The ovary of the female is of the same structural type as *I. montserratensis*. The chromosomes are identical with those of *I. montserratensis* in number, size, shape, and behavior. All eggs undergo reduction. If fertilized these eggs give rise to females characterized by the diploid chromosome number; if they are unfertilized they develop parthenogenetically into haploid males.

Considering the breeding and cytological evidence together it is clear that *Icerya littoralis* is a normally bisexual species such as *I. montserratensis* without any trace of the hermaphroditic habit. In common with both *I. purchasi* and *I. montserratensis*, however, it shows the facultative parthenogenetic production of haploid males. Fertilization of the eggs of the female by the sperm of these males is necessary for the production of female offspring.

Echinicerya anomola Morrison.

A single and very limited occurrence of this interesting new Iceryine was found on one tree, an unidentified species of Acacia, in the vicinity of Quirigua, Guatemala, in March 1928 and again in the same region in 1929. On both occasions all

nymphal instars were present, suggesting more or less continuous breeding throughout the year as in Icerya. The adult females are very striking in appearance, making recognition in the field easy. The four anterior median dorsal wax tufts are prolonged into stiff spines of which the fourth or most posterior is longest. The females form no egg-sacs whatsoever; the eggs are deposited under the body of the parent which becomes increasingly concave ventrally as egg laying goes on.

The ovary of the female shows the anterior fusion of right and left halves characteristic of all other margarodids reported so far. Certain variations are characteristic; the ducts connecting the ovaries with the vagina are very long in comparison with the Icerya condition, thus restricting the ovaries proper, or actual egg bearing portion of the gonad to the anterior half of the organ. The spermatheca is constantly present and attains a development comparable to that in *I. montserratensis* or *I. littoralis*.

There is no trace of hermaphroditism in any instar in either sex. In cytological detail there is surprising correspondence with the *Icerya montserratensis* and *I. littoralis* condition. Females of all instars are diploid, with a chromosome number of four; males are always haploid, with the reduced chromosome garniture of two. All the eggs of the female undergo reduction. If fertilized the diploid number is restored and development into a female results. Unfertilized eggs are also capable of development, and as in the other species described, they never restore the diploid chromosomes but develop into haploid males. In the ovaries of fertilized females (so determined by the presence of sperm bundles and loose sperm in their ovarian ducts) both haploid and diploid embryos are found. In unfertilized females, (those showing no sperm within ovaries or ducts) only haploid embryos are found. Although no breeding experiments were possible with this species, the cytological evidence just given, together with the close similarity to *I. montserratensis* and *I. littoralis*, indicate pretty clearly that the reproductive processes involved are the same as in the two last-named species.

Crypticerya rosæ Cockerell.

A very slight infection of *Crypticerya rosæ* was found in February, 1928, near Orange Walk, British Honduras, on a species of Inga locally termed the Guama tree. The adult

female resembles Icerya in body form but is more convex and almost completely devoid of wax dorsally. As in Echinicerya no egg-sac whatever is made, and the eggs are laid under the body of the female, a few at a time, probably over quite a period of time. The only adult female in my collection was neatly covered with an ant carton. The prevalence of certain coccinellid beetle larvæ which prey upon these large soft bodied coccids suggested that only females so protected had survived in this *vicinity.*

No breeding work was undertaken on this species and the small number of individuals found were all preserved for cytological study. This material includes one adult female whose huge ovary contains a large number of embryos in practically all stages of development from the maturation of the egg to late embryos almost ready to hatch—one second instar nymph, and eight larvæ of the first instar. The female shows no trace of hermaphroditism. The ovary is of the type described in Icerya and Echinicerya, with a striking increase in the relative length of the ducts which connect the vagina with the ovaries proper. In respect to this character the Iceryines thus far studied form a series with *Icerya purchasi*, with its very short ducts, at one end, and *Crypticerya rosæ*, with its exaggerated ducts, at the other. In all these species the spermatheca is small and subject to variation in size, and indeed it may occasionally be absent entirely in *I. purchasi.* In none of the forms studied is there any evidence that it functions for the storage of sperm; after copulation the sperm from the male are found in the oviducts and the central cavity of the ovary itself, never, in many specimens examined among the different species, in the spermatheca. Neither is there ever any development of gland cells in its epithelium. Its function remains entirely problematical.

The chromosome number in the oogonia and somatic tissues of the female is four. Normal maturation figures are found in the younger eggs, showing the formation of two tetrads quite as in Icerya. Both haploid and diploid embryos are present in large numbers. The second instar nymph is a male with the somatic and spermatogonial chromosome number of two—the haploid group. Of the first instar larvæ, four are diploid, two are haploid, and two show no legible mitoses. Although incomplete, this cytological evidence certainly indi-

cates that *Crypticerya rosæ* is capable of the facultative parthenogenetic production of haploid males, while its females arise from normally fertilized eggs and are hence diploid. To be sure adult males of *Crypticerya rosæ* have never been reported, but when one considers their seasonal appearance, and the small size and great fragility of the males of closely related species, it is not surprising that the few random collections recorded for this species fail to contain any. The present discovery of haploid embryos, haploid larvæ of the first instar, and a typical haploid male nymph of the second instar, when considered in connection with the close cytological parallelism obtaining between this species and *Icerya montserratensis*, *Icerya littoralis*, and *Echinicerya anomola*, makes the existence of adult males in Crypticerya practically certain.

That the haploid embryos and larvæ arise from eggs fertilized by sperm from a male, and not from an hermaphroditic phase in the female is almost certain since the gonad of the adult female shows no traces of an earlier male phase, such as are usually apparent in adult hermaphrodites of *Icerya purchasi*. Furthermore, the young diploid larvæ of the first instar show no trace of an incipient male phase in their developing gonads, such as would be present in *corresponding* stages in the hermaphrodites of *Icerya purchasi*.

General Considerations.

Perhaps the most striking result of the foregoing studies is the fact that the functional hermaphroditism of *Icerya purchasi* emerges as a unique phenomenon, not suggested nor approached in any way by any of the other Iceryine types investigated. That this development of the hermaphroditic habit in *Icerya purchasi* is not a primitive characteristic of the species is perhaps abundantly clear from such facts as the persistence of the now entirely unnecessary males within the species, and the retention of the mating instincts of females on the part of the hermaphrodites. What is known of the biology of other members of the Margarodidæ supports the further opinion that the hermaphroditic habit can certainly not be considered a basic or primitive character of the family. Kuwana's studies on Drosicha (Warajicoccus, Kuwana '22a) and Stebbing's earlier work on Monophlebus ('04) indicate

clearly that fertilization by a male is essential for reproduction in these forms. Schrader's recent study on *Protortonia primitiva* establishes the same relationship for that species. In these forms, representing three different tribes of the Margarodidæ, there is certainly no trace of hermaphroditism. The hermaphroditic habit is thus clearly neither a family nor a tribal character, and is to be considered a secondary and derived condition in the one species now known to possess it.

Once established, functional hermaphroditism obviously offers an extremely efficient and successful mode of reproduction. With this in mind a comparison of the reproductive habits of those Margarodids now thoroughly well known in this respect becomes of interest. Schrader ('30) suggests that one reason for the extreme scarcity of *Protortonia primitiva* in its native territory and among an abundance of its food plants, is to be found in the precarious relations characterizing its mating behavior. The short adult life of the males, and the equally short period in which the females are capable of being fertilized, taken together with the great variation in length of the different larval instars under changing environmental conditions undoubtedly tend to keep the number of successful matings relatively low. To the action of this factor in Protortonia is to be added the very small size of the brood produced by the individual female. The four Iceryines of the present study, *Icerya montserratensis*, *Icerya littoralis*, *Echinicery aanomola*, and *Crypticerya rosæ*, show in one respect at least a more successful mode of reproduction. The same precarious mating conditions exist as characterize Protortonia, but the parthenogenetic production of males does much to offset this. Although the males are equally frail and short lived they are produced in such large numbers (compared with the nonparthogenetic Protortonia) that the chances of any one female being fertilized are tremendously increased. This advantage I believe to be partially offset by a weakening of the mating instinct in the Iceryine males studied. When compared with the behavior of the males of such an obligatorily bisexual species as Protortonia, the males of these Iceryines show a marked lack of ardor and a very slow and variable response to the females. When compared with either the Protortonia or the *I. montserratensis* (as an example) type of reproduction, the hermaphroditic habit of *I. purchasi* appears to be very much

more efficient; rendering the frail and short-lived males unnecessary to the propagation of the species has certainly removed the weakest point in the reproductive mechanism. My experience with these species in the field supports this general conclusion. *Icerya purchasi* shows the largest and most flourishing colonies of any of the types studied, wherever found. Its success in establishing itself in a wide range of localities following accidental introduction is an added argument. Protortonia on the other hand is much more limited in geographical distribution and very scarce and very sporadic where it does occur. The limited evidence available on the other forms would give them a position intermediate between *I. purchasi* and Protortonia in this respect.

The five Iceryine species here discussed are further remarkable, it seems to me, for an amazing degree of uniformity relative to many of their characters. In each species the males are haploid and arise parthenogenetically from unfertilized eggs. In cytological detail there is also surprising agreement. Not only are the diploid and haploid chromosome numbers the same in all, but the individual chromosomes show a close agreement in size, shape, and details of cytological behavior. The structure of the ovary is another indication of the close relationship evident throughout. The conclusion is highly probable that the mode of reproduction characteristic of this group of closely allied species will prove to be a basic character of the tribe, with the hermaphroditism of *Icerya purchasi* and the resultant reduction in its males as an isolated deviation.

The species reported in the present study represent three of the six genera comprising the Tribe Iceryini. Of the other three, nothing at all is known of the reproductive processes in Steatococcus Ferris or in Auloicerya Morrison. The remaining genus Gueriniella Fernald has been intensively studied by Vaysierre ('26). This species has a single generation per year in the Mediterranean region. The eggs are laid in mid-summer and the larvæ hatch some weeks later, but do not attach themselves to the host plant until the following spring. The actual period of development, omitting this long quiescent period, is three to four months, as in the other Iceryines. But from the point of view of the present study Gueriniella is most interesting because of the absence of males. Males are completely unknown in this species, and since it has been the subject of careful

breeding experiments by Vaysierre, this probably means that they do not exist. (Vaysierre does not, however, take up this aspect of the subject in his study.) It is possible, therefore, that Gueriniella is either hermaphroditic or obligatorily thelytokously parthenogenetic. If hermaphroditic it would seem to have carried the reduction of the males, in which process *Icerya purchasi* represents a transitional step, to its ultimate conclusion. Only a cytological examination can settle this interesting and outstanding question.

LITERATURE CITED.

Hughes-Schrader, S. '25. Cytology of hermaphroditism in Icerya purchasi (Coccidae). Zeit. f. Zellforsch. u. mik. Anat. 2.

———. '26. Spermatogenesis in Icerya purchasi—a correction. Science, 63.

———. '27. Origin and differentation of the male and female germ cells in the hermaphrodite of Icerya purchasi (Coccidae). Zeit. f. Zellforsch. u. mik. Anat., 6.

Johnston, C. E. '12. Internal anatomy of Icerya purchasi. Ann. Ent. Soc. Amer., 5.

Kuwana, I. '22a. Studies on Japanese Monophlebinae Contribution I. The genus Warajicoccus. Dept. Agric. and Com. Imp. Plant Quar. Sta. Bul. 1.

———. '22b. Studies on Japanese Monophlebinae Contribution II. The genus Icerya. Ibid. Bul. 2.

Leonardi, G. '20. Monografia delli Cocciniglie Italiane. Stab. tip. Ernesto della Torre.

Morrison, H. '28. A classification of the higher groups and genera of the coccid family Margarodidae. U. S. Dept. Agric. Tech. Bul. 52.

———. '30. An interesting new genus of Iceryine Coccid. Proc. Biol. Soc. Washington, Vol. 43.

Pierantoni, U. '10. La symbiosi ereditaria e la biologia sessuale d'Icerya. Monit. Zool. Ital. anno 21.

———. '12. Studio sulla sviluppo d'Icerya purchasi Mask. Parte I. Arch. di Zool. Ital. 5.

———. '14a. *Ibid,* Parte II. Arch. di Zool. Ital. 7.

———. '14b. *Ibid,* Parte III. Arch. di Zool. Ital. 7.

Riley, C. V. '86. Icerya purchasi. An. Rep. U. S. Entomologist.

Riley, C. V. and Howard, L. O. '90. Some new Iceryas. U. S. Dept. Agr., Div. Ent. Insect Life, 3.

Schrader, F. '23. A study of the chromosomes in three species of Pseudococcus. Arch. f. Zellforsch. 17.

———. '29. Experimental and cytological investigations of the life-cycle of Gossyparia spuria (Coccidae) and their bearing on the problem of haploidy in males. Zeit. f. wiss. Zool. 134.

———. '30. Observations on the bidogy of Protortonia primitiva (Coccidæ.) Ann. Ent. Soc. Amer.

Schrader, F. and Hughes-Schrader, S. '26. Haploidy in Icerya purchasi. Zeit. f. wiss. Zool., 128.

Shinji, G. O. '17. Mating habits of Icerya purchasi. Entom. News, 28.

Stebbing, E. P. '04. On the life history of a new Monophlebus from India. Jour. Linn. Soc. London, 29.

Thomsen, M. '27. Studien ueber die Parthenogenese bei einigen Cocciden und Aleurodiden. Zeit. f. Zellforsch u. mik. Anat. 5.

Vayssiere, P. '26. Contribution a l'etude biologique et systematique des Coccidae. Ann. des Epiphyties 12.

THE MOULTING OF THE SILKWORM AND A HISTOLOGICAL STUDY OF THE MOULTING GLAND.

SIBYL WACHTER,
Stanford University.*

Insects during the process of post-embryonic development periodically shed or moult their cuticular covering, and in addition the lining of such internal parts as are of ectodermal origin. The number of moults depends upon the number of growth periods and varies in the different species of insects. In the silkworm *Bombyx mori*, the species under observation, there are five of these growth periods, or "instars," in addition to the pupal stage. At the end of each, actual ecdysis takes place. However, sometime before ecdysis takes place, certain glands of ectodermal origin become active and liberate a fluid known as "moulting fluid," which has an important function in the process of moulting. This fluid assists in the process, and the glands furnishing the fluid are highly important organs physiologically.

The present study of the moulting of the silkworm was made during the months of April, May, and June, 1929, on some hundred specimens as they developed from the egg to adult. Silkworms were reared individually in wide-mouth fruit jars three by four inches in size. They were fed mulberry leaves two to three times a day. The temperature of the breeding room ranged from a maximum of 81° Fahr. to a minimum of 63° Fahr. The median temperature of the observation period was 72° Fahr. Observations were made constantly during the time of the moulting activity. A binocular microscope was used for close observation. All observations refer to the fourth moult, as these larger specimens permit of more accurate study, and the similarity between the first four moults is very marked. For histological study of the moulting cells whole insects were killed in boiling water, the body cut into segments, and each segment was dehydrated, imbedded in paraffine, sectioned, and stained in Delafield's haematoxylin. Mounts were made of sections of insects during the moulting period. Studies were made under an oil emersion lens. The following account is based on the results of observations.

*Contribution from the Entomological Laboratory of Stanford University, California.

The First Indications of Ecdysis

The first external indications of a change taking place in the silkworm at the time of the moult occurs about thirty-six hours before ecdysis. At this time the cuticula becomes decidedly glossy in character. There appears to be a thickening of the subcuticular layer. The increase of the chitinous substance by the chitogenous or hypodermal cells is no doubt responsible for the glossy effect characteristic of the integument of the larva. This change is gradual but is noted very definitely before there is any external sign of a new body developing within the old skin.

Shortly after this is apparent close observation shows a very slight slipping out of the tracheal lining at the dorsal point of the peritreme. This appears as a dark area or point above the spiracle. The moulting glands are functioning and the fluid is spreading rapidly between the old cuticula and the new integument forming beneath it. Thus the contacts between these two layers are being attacked and dissolved as pointed out by Tower. In time the new body is fastened to the old skin merely by the muscle attachments which are the last parts to be dissociated. As the cuticula of the peritreme becomes definitely free, the tracheal lining is pulled out at the sides so that the dark area widens laterally toward the ventral side of the peritreme and finally is complete as a circular band extending around the spiracle.

The Triangle Stage.

Following this there is a distinct change in the appearance of the head and thoracic region. This occurs after the larva is well established on the leaf with the silken mesh of threads beneath it, to which it has attached its prolegs. The larva has been inactive for several hours. Gradually there is a slight increase in color back of the larval head. The old cuticula at this point becomes turgid with included fluid. The strain on the cuticula draws the head and thorax with the fore legs into a more fixed, upright position. Within a few hours the new head is visible beneath the old cuticula. It shows as a brown, pigmented, triangular area posterior to the old head capsule with one angle of the triangle directed posteriorly and the other two angles encircling the head capsule and joining ventrally. This period is referred to as the "triangle stage" of the moult. The "triangle" when viewed under the microscope shows the chitinized texture of the new head though the markings and sutures are not definitely visible until just preceding ecdysis when the old cuticula becomes very transparent and the head has grown further back into the old prothoracic region. As the new head presses the posterior area further backward, the old cuticula becomes more and more stretched in the thoracic region. The anterior portion of the new head extends into the old head capsule, which is now dry and has hardened into a mere shell. The labium of the new head is stretched and pressed very tightly against the base of the old capsule ventrally, while the frontal portion with the clypeus and labrum is held less tightly in the dorso-anterior part. All intervening space is filled with fluid.

The transparency of the old cuticula, which makes it possible to observe the newly developed parts within, is apparent first in the region of the new head and around the peritremes where the linings of the old tracheæ are pulled loose. It seems evident that the moulting fluid must play an important part in accomplishing this thinning and consequent transparency which increases from hour to hour as the time for ecdysis approaches. The new body appears in heavy folds beneath the cuticula. This is especially evident in the thoracic region and results no doubt from the rapidly growing parts being crowded together within the confines of the outer wall of the old body.

Muscular Efforts.

About an hour or so before ecdysis certain muscular activities predict the approaching event. Throughout the "triangle stage" the larva has been inactive in its fixed position on the leaf. Now there are muscular pulls on the integument which become more and more vigorous in character. The action consists of the pulling of the old cuticula at the points of the muscle attachments. It is a rhythmical pull which centers anteriorly to the spiracle in each segment. It spreads posteriorly along the lines of the muscle attachments dorsal and ventral to the spiracle until it reaches a maximum lateral pull and effects the whole of the integument including a definite upward pull on the prolegs and true legs. Before the maximum lateral pull is noted, however, there is a dorsal pull on the cuticula at the depths of the folds of the thorax and at a mid-dorsal point of the anterior end of each abdominal segment. The lateral pull is more strenuous in the posterior segments first. The dorsal pull appears to spread from the anterior segments. This pull appears to have something to do with the spread of the moulting fluid and perhaps with its exudation from the moulting glands. When the muscular action is slight, the pull is almost simultaneous in each segment. As it increases in vigor, the cuticula is pulled in irregularly and independently at different points. The pull then appears to be localized at each point.

Fluid Pressures.

[illegible]he activity in the prolegs is evident about thirty minutes preceding e[illegible]is when the outline of the new proleg is defined within the old ca[illegible]e. At the base of each proleg there is a heavy fold of cuticula bu[illegible] out apparently with a fluid contained within, as in the case of th[illegible]iangle" area of the thorax previous to the appearance of the [illegible] This fluid soon fills in the area between the new proleg and the old proleg capsule. The new proleg lies freely in the liquid of the proleg capsule still attached basally by ligaments to the basal wall of the old capsule. It is now and then retracted or telescoped into its basal part by the muscular attachments. This action increases in vigor and accompanies the lateral and dorsal contractions of the body previously described.

There is definitely a pressure established within the body preceding the final shedding of the skin. This is most evident in the last twenty minutes of the moult. As the old cuticula becomes completely separated in the thoracic region, from the new, the inner body swells

and fills out and straightens the folds in the integument previously noted in this region. The new proleg becomes turgid with blood from the body cavity and forces the moulting fluid out of the old capsule. As the swelling subsides the prolegs are withdrawn from the leg capsules which consequently shrink closely to the body wall. At this time the new body within shows clearly over the entire surface, though the similarity of details of the outer and inner do not make this distinct except where the swelling of the new body has shifted the inner parts forward so that the markings contrast with those above. In the anterior region the fluid beneath the cuticula is withdrawn. This creates a suction which draws the cuticula closely to the underlying parts causing it to fall into creases. There is a general wrinkling of the outer cuticula over the whole body. It would appear that this was due also to the withdrawal of excess moulting fluid.

Air and Fluid in the Alimentary Canal.

At the time when this swelling of the inner body is noted it is evident that air is drawn into the alimentary canal. Careful observations also show that the head capsule is filled with a fluid which is constantly sucked backwards. By pulling away parts of the old head capsule so as to expose the new head and pharyngeal cavity, the fluid, which fills all the space within the old capsule not occupied by the new head, can be drawn off in droplets. Normally this fluid which continues to gather throughout this period is taken care of within the body as none is evident here at the time of ecdysis. Observations show that this fluid is sucked internally into the alimentary canal. As the fluid ceases to gather, the sucking movements continue thus drawing air into the alimentary canal until ecdysis is complete.

Monnier (1872) in aquatic larvæ, de Bellesne (1877) in Odonata, Herculais d' Kunckel (1890), Knab (1919, 1911), Shafer (1923) have all recognized the fact that mechanical pressure forces the blood against the body wall and thus enables it to exert a pressure against the outer integument which accomplishes the rupture at ecdysis, and that this pressure is established by an accumulation of air in the alimentary canal. Monnier (1872) first recognized the presence of air in the alimentary canal and its function, but de Bellesne first observed that this air was swallowed by the insect. The swallowing of liquid has not been previously noted, though Shafer noted the presence of a "fluid more viscous and less transparent than water" in the alimentary canal of Odonata after the moult.

In the silkworm there is a throbbing action in the clypeal region of the head accompanying the sucking movement of the pharynx. The tissue is drawn in at regular intervals. The fluid collects within the mouth cavity in the epipharyngeal region. Though no moulting glands have been found located in the head and the origin of the fluid is not explained, yet it seems to be related to the moulting fluid. As the mouth cavity is filled with fluid, the open mandibles close upon it and work it backwards with a regular and vigorous pull. At the same time the hypopharynx works in the same direction and within a minute, or less, of the time when the mouth cavity is full, the fluid is

sucked into the alimentary canal and the mouth cavity is empty again. There appears to be no excess of fluid drawn away with the stomodaeum when it is pulled away with the head capsule either artificially or naturally. It would appear therefore that all the excess fluid as well as that which appears to gather within the mouth cavity at this time is gulped down the oesophagus with or before air is swallowed The effect of swallowing fluid and air would be to dilate the digestive tube. The fixed quantity of blood in the body, as pointed out by Knab, Shafer, and others, is driven to the periphery of the haemocoel by pressure exerted by the dilated digestive tube, thus obtaining the necessary force to accomplish ecdysis.

It may be noted here that this is the same mechanism which initiates and accomplishes the expansion of the wings of the young imago, by means of blood forced out through them, and also aids certain insects to elongate the body for the purpose of ovipositing, (Herculais d' Kunckel, 1894). It is this mechanism which enables certain insects at least to effect the hatching process from the egg covering, (Hubbard, 1885, *Psocid citricola* Ash; Peyerimhoff, 1901, *Stenopsocus cruciatus* L.; Wachter, 1925, *Ectopsocus californicus* Banks.)

The principle of the inflation of the digestive tube with air, as fundamental in the moulting, hatching, and other processes in insects is thus a well-established one. In addition, as here pointed out, more or less liquid secretion is also drawn into the digestive tract. Muscular exertions unaided appear to be inadequate to liberate the insect from the exuviæ, as Knab and others have stated. The new chitinous cuticula is too soft to offer much resistance to the pull of the muscles now inserted here.

The Ecdysis.

The maximum swelling due to the air and fluid which is being steadily drawn into the digestive tract exerting a pressure upon the body wall occurs in the anterior of the body immediately preceding ecdysis. Simultaneous with the swelling there is a shortening and lengthening in the horizontal direction between the segments. This activity begins in the posterior segments and advances in waves forward. It arises first in the region of the sixth abdominal segment but the initiation of the wave recedes to the seventh, eighth and posterior region of the body before ecdysis is complete. As the forward part of the body is forced against the contact between the head capsule and the thoracic cuticula, the pressure becomes so great that a rupture in the old cuticula results. This is a circular tear starting near the labium at a mid-ventral point and extending around the old head capsule where it is attached to the neck membrane. With the first break in the cuticula the new body bulges out and appears as a small nob at the base of the head but this disappears immediately as the slit continues around the lateral contacts. The contact at the mid-dorsal point holds just long enough to cause the head to be drawn up and back. This last attachment snaps quickly. The head is now greatly inflated with blood, and when the rupture is complete the posterior parts of the new head are grasped tightly by the neck membrane thus avoiding any loss of pressure within the body necessary for the com-

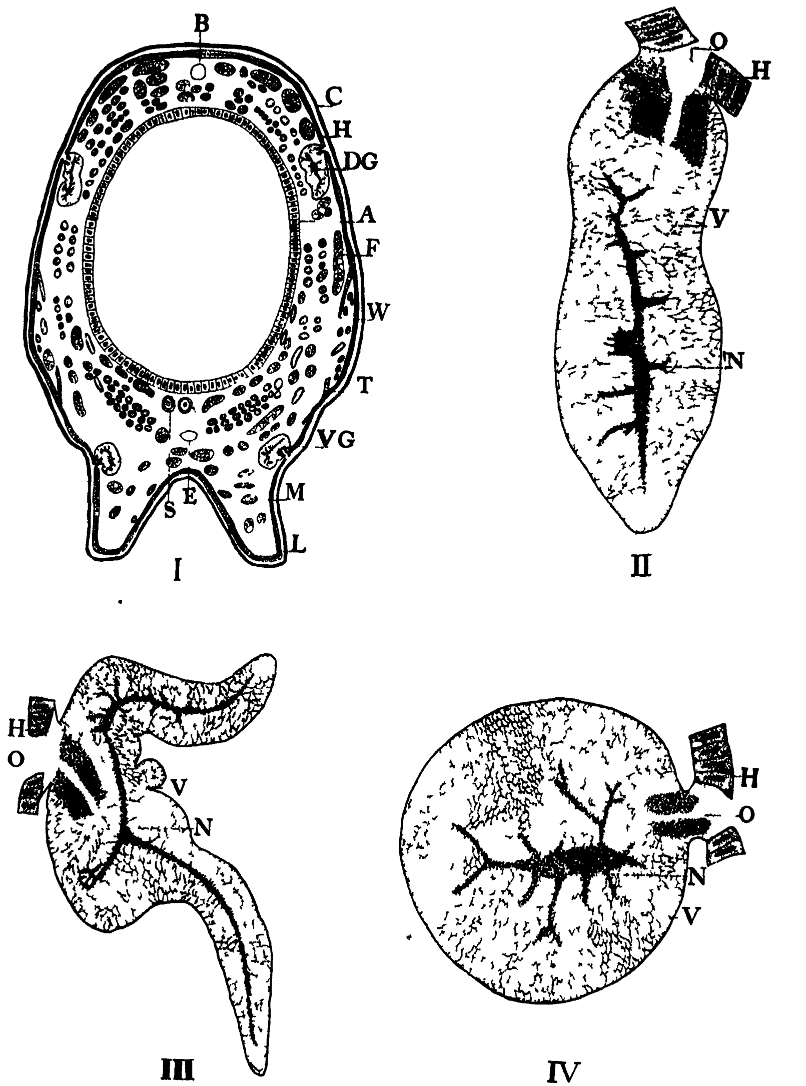
pletion of the moult. The rupture is sudden, and the old head capsule is expulsively thrown off followed by a forward movement of the new body out of the old cuticula. After the rupture the head assumes a normal position and the old capsule, which is the only part forced off by the rupture, sometimes clings to the anterior end enclosing the new mandibles until it is removed by rubbing it against the leaf or with the aid of the fore legs. The slipping off of the old skin takes about a minute.

As previously stated, a forward movement of the body begins beneath the old integument before the rupture takes place. The anterior prolegs are entirely withdrawn from their capsules. The second, third, and fourth abdominal segments apparently are the first to move forward, as here the tracheal linings are seen to be pulled out from the corresponding tracheæ as these segments move forward. The tracheal linings, now apparently without air, are seen stretching along the side of the body backward from the new spiracle to the old. The first and fifth abdominal segments then take part in the movement as evidenced by the relation of the corresponding exuviated tracheal tubes and their corresponding spiracles, old and new. The lining of the thoracic tracheal tube now slips out in a dorsal direction instead of posteriorly as in the case of the other tracheal tubes. The pressure here is upward as the thorax is swelling previous to the rupture. The thoracic tracheal linings and the linings of the tracheæ in the posterior three abdominal segments are the last to be pulled out of their corresponding tracheal tubes, and hence the corresponding spiracles are presumably the last to remain functional during the process of tracheal ecdysis. The posterior tracheal linings remain intact after the rupture, and after the slipping back of the old cuticula at the anterior of the body has begun. The backward movement of the cuticula is so rapid after the rupture actually takes place that the spiracles of the anterior end of the body begin to function before the tracheal linings are pulled out of their corresponding tracheal tubes in the posterior end of the body. Thus there is almost no interval when respiration may not take place either at the posterior or anterior end of the body during moulting.

The Moulting Glands and Their Fluid.

Newport (1832) is said by Packard to be the first one to have observed the moulting fluid. However, according to Swammerdam Malpighi, Professor of Physics and Philosophy in Bologne, publishing his observation on the Metamorphosis of the Silkworm in 1669, states with reference to the pupal ecdysis that "this process is assisted greatly by a yellow kind of ichor or fluid which breaks forth in the cavities of the skull." The gland cells which furnish this fluid have been designated by Holmgren (1895) as Verson's glands, as it was he who made the first detailed study of these glands in the silkworm.

In the silkworms under observation at a time preceding the moult from ten to thirty hours, these glands have a very similar structure in all segments but differ somewhat in size, position, shape, and distribution of nuclear material. Each gland is a single giant cell. The nuclear



THE MOULTING GLANDS OF THE SILKWORM.

Fig 1. Cross-section through metathorax DG, Dorsal moulting gland VG, Ventral moulting gland A, Gut B, Aorta C, Old cuticula. E, Nerve cord F, Fat cells H, Hypoderm L, Leg M, Muscle. S, Silk gland duct W, Position of imaginal wing in sections posterior to this T, Trachea

Fig 2 Dorsal gland of third abdominal segment.

Fig 3 Dorsal gland of first abdominal segment

Fig. 4. Dorsal gland near anal horn of eighth abdominal segment O, Opening of gland. H, Hypoderm V, Vacuolated cytoplasm N, Nucleus.

material is spread out along the line of the length of the cell, (Figure II-N). Fine radiations from the main branches are numerous especially at the wider portions of the gland. In some cells it is concentrated in the central region with branches extending from this, (Figure IV-N). If the gland has finger-like lobes, the branches of nuclear material extend into these lobes, (Figure III-N). Outside of the nuclear material the gland is distinctly vacuolated everywhere (Figures II, III, IV -V) except at the point where it is in contact with the hypodermal layer. Certain hypodermal cells surround the tubular duct of the gland and appear as a guard to that opening. The intima of the normal hypodermal cells appear to be continuous around the surface of the gland.

As determined by Verson, there are fifteen pairs of moulting glands in the silkworm. They are large and conspicuous and situated as follows: A dorso-lateral pair in each thoracic and each abdominal segment, namely eleven dorso-lateral pairs of glands; a pair at the base of each of the thoracic legs, namely, three latero-ventral thoracic pairs; and a pair at the base of the anal horn. The dorso-lateral glands are found in the anterior half of each segment and extend backward within the segment. Antero-posteriorly, these glands vary little in length from segment to segment. Ventro-dorsally, there is a slight difference in the vertical and horizontal diameters. Those in the anterior abdominal segments have a vertical diameter twice or three times that of the horizontal diameter, (Figure II). Those in the posterior segments appear about the same in vertical and horizontal diameters, (Figure IV). There is considerable irregularity in the width of these glands as a whole, as observed in cross sections, (Figures II, III, IV). The shape of the glands is in general elongate-tubular with many irregularities in the form of finger-like extensions, (Figure III). In the same segment the gland on one side may be regular in its long, narrow form while that on the other has projecting lobes. This irregularity would indicate that the shape varies with the functioning of the gland. The glands in one area may function at a different time from those in another area. The dorso-lateral glands are all located about midway between the spiracle and a mid-dorsal line, and open at the surface dorso-laterally, (Figure I–DG). The pair at the base of the dorsal horn of the eighth segment is very close to the mid-dorsal line. Each one opens to the surface on either side of the dorsal blood vessel. The ventro-lateral glands are located just above the attachment of the leg to the body and open ventrally at the base of the leg, (Figure I–VG).

SUMMARY.

In the previous observations, several important physiological features of the moult are noted. The first of these is the formation of an inner layer of chitin by the hypodermal cells active as chitogenous cells. This is perhaps the first step in the moulting process. At this time the insect has barely ceased feeding, and the last pellet of foecal matter has not been eliminated. The insect is in the stage which might be called

the "glossy stage." Packard considers that the "formation of the new layer of chitin arrests the supply of nourishment to the old skin, so that it dries, and hardens. The next step is the exudation of the moulting fluid which spreads out as a thin sheet of liquid between the old and new cuticula and finally fills all available pockets such as the head capsule, the proleg and leg capsules, and the dorsal horn as the respective parts are withdrawn from these. This fluid is an important feature of the process of moulting. It is furnished by certain highly-modified hypodermal glands known as "exuvial glands."

BIBLIOGRAPHY.

De Bellesne, J. Phénoménes qui accompagnent la métamorphose chez la Libellule déprimée. Compt. Rend. Acad. Sci. Paris, Vol. 85, 1877, pp. 448-450.

Henneguy, L. F. Les Insectes. Masson et Cie, Éditeurs, Libraires L'Academie de Médicine 120, Boulevard Saint Germain (VI) Paris, 1904, pp. 495-503.

Holmgren, E. Studier öfver hudens och de körtelartade hudorganens morfologi hos skandinaviska Macorlepidopter-larven. K. Svenska Ventenskaps Akad. Akad. Handl., Vol. 27, 1895, (Reviewed by Plotnikov, p. 336).

Hubbard, H. G. Insects Affecting the Orange. Misc. Doc. 40, Hse. Repres. Wash., 1885, p. 195.

Knab, F. The Role of Air in the Ecdysis of Insects. Proc. Ent. Soc. Wash., Vol. ii, 1909, pp. 68-72. Ecdysis in the Diptera. Proc. Ent. Soc. Wash., Vol. 13, 1900, pp. 32-42.

Kunckel, D' Herculais. Méchanisme physiologique de l'éclosion des mues et de métamorphose chez les Insects Orthoptéres de la famille des Acridides. Du role de l'air dans le mécanisme physiologique de l'éclosion, des mues et de la métamorphose chez les Insectes Orthoptéres de la famille des Acridides. Comp. Rend. Acad. Sci., Vol 110, 1890, pp. 657-9, 807-9. Mécanisme physiologique de la ponte chez les Insectes Orthoptéres de la famille des Acridides. Role de l'air comme agent mecanique et fonctions multiples de l'armure génitale. Comp. Rend. Acad. Sci. Vol. 119, 1894, pp. 244-247.

Malphigi, M. Dissertatio Epistoloca de Bombyce, Regiae Societati dicata, (reviewed in Trans. Royal Soc. London. Vol 1, 1669, p. 367-69).

Monnier, M. Sur le role des organes respiratoires chez les larves aquatiques. Comp. Rend. Acad. Sci., Vol. 74, 1872, p. 235.

Newport, G. On the nervous system of Sphinx ligustri L. and on the changes which it undergoes during a part of the metamorphoses of insects. Phil. Transact. London, 1832, pp. 383-98.

Packard, A. S. A Textbook of Entomology. New York, 1909, pp. 609-18, The Macmillan Co.

Peyerimhoff, P. Le mécanisme de l'éclosion chez les psoques. Ann. Soc. Ent. France, Vol. 70, 1901, pp. 149-152.

Plotnikov, W. Über die Hautung und uber einige Elemente der Haut bei den Insekten. Zeit. wiss. Zool., Vol. 76, 1904, pp. 333-366.

Shafer, G. D. The Growth of Dragonfly Nymphs at the Moult and Between Moults. Stanford Univ. Pub. Unive. Series. Biol. Sci., Vol. 3, 1923, No. 4.

Swammerdam, J. The History of Insects. London, 1738. Printed for C. G. Seyffert, Bookseller.

Tower, W. L. Observations on the Changes in the Hypodermis and the Cuticula of Coleoptera during Ecdysis. Biol. Bul. of the Marine Biol. Lab., Woods Hole, Mass., Vol. 10, 1906, pp. 176-192.

Verson, E. Hautdrüsensystem bei Bombyciden (Seidenspinner). Zool. Anz., Vol. 13, 1890, pp. 118-120. (Reviewed in the Journal of the Royal Microscopical Society and in Henneguy's Les Insectes.

Wachter, S. The Hatching of the eggs of Peripsocus californicus Banks (Ectopsocus). Pan Pac. Ent., Vol. 2, 1925, pp. 87-89.

A DESCRIPTION OF THE MALE OF PROCERATIUM CROCEUM EMERY, WITH REMARKS.

M. R. SMITH,
A. & M. College, Mississippi.*

Although the genus *Proceratium* was erected by Roger in 1863, the few species in this genus are known only from the worker and female phases. This has been due probably to the following reasons: either that myrmecologists have neglected to describe the males which they have collected, or they have not been fortunate enough to find the males associated with the females or workers, or they have failed to collect the males at all.

Three species with several subspecies and varieties have been recorded for North America. The most common of these in Mississippi, at least, is the species *P. croceum*, the colonies of which I have usually found in rotting stumps and logs. Although this is not a rare ant in Mississippi, it is by no means a common species. The colonies of *P. croceum* are very small. In one of the largest colonies that I have found there was a dealate queen and 30 workers. In a smaller colony I found 1 dealate female and 11 workers. It is not unusual to find a single dealate queen alone.

During the summer of 1929 I was fortunate enough to find a colony of *P. croceum* which in addition to workers contained both alate males and females. From some of these specimens I have drawn the description given below. Since this is the first male to be described for the genus I have thought it advisable to present figures also.

I am indebted to Dr. W. M. Wheeler for his opinion concerning the taxonomical status of the ants, and to Mrs. G. G. DeBord for the accompanying illustrations.

Proceratium croceum (Roger).

P. croceum (Roger), Berl. Ent. Zeitschr., Vol. 4, p. 288 (1860), female (*Ponera crocea*).

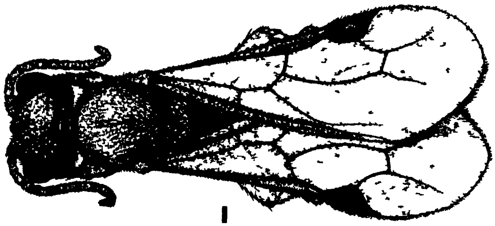
Sysphingta? crocea, Mayr, Sitzungsb. Akad. Wiss. Wien, Vol. 53, p. 501 (1866), female.

P. croceum Mayr. Verh. Zool. Bot. Ges. Wien, Vol. 36, p. 437 (1886); Emery, Zool. Jahrb. Syst. Vol. 8, p. 264, Pl. 8, f. 5; 6 (1895), worker and female.

* A contribution from the Mississippi Agricultural Experiment Station.

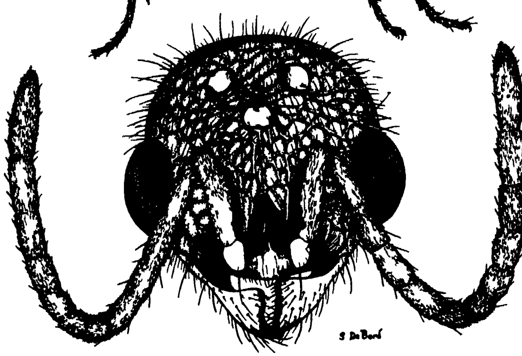
Male Length: 3 75–4 25 mm

Head, excluding the mandibles, slightly broader than long when measured from side to side through the center of the eyes, posterior border and posterior angles strongly rounded Vertex with 3 fairly prominent ocelli, the distance between one of the lateral and the median



1

2



3

Male of *Proceratium croceum* (Roger)
Fig. 1, Dorsal view of body. Fig. 2, Lateral view of body.
Fig. 3, Anterior view of head. (All greatly enlarged.)

ocellus less than that between the two lateral ocelli. Eyes large and prominent, oblong-oval, strongly convex. Antennæ 13-segmented, subfiliform; scape short, moderately stout, not attaining the anterior border of the median ocellus; last funicular segment slightly longer than the two preceding segments taken together. Frontal carinæ

short, subparallel, not concealing the pedicels of the scapes. Region of the frontal area deeply impressed. Anterior border of the clypeus broadly, but gently emarginate medianly. Mandibles well developed, subtriangular, the apical margins of each edentate and strongly sinuate, terminating in a sharp apical point. Thorax short and massive. Pronotum well developed, easily discernible dorsally, with rather distinct humeral angles. Mesonotum without Mayrian furrows but with fairly distinct parapsidal sutures posteriorly, the anterior median portion of mesonotum subtruncate, and fitting into the deep, central emargination of the posterior border of the prothorax. Wings sordid brownish; pilose throughout, and with ciliated margins; the anterior pair, each with a very large and distinct stigma, and an open radial cell, a closed cubital cell, but no discoidal cell. Scutellum with a distinct median carina posteriorly. Metanotum terminating centrally in a large, pointed tooth or tubercle. Base of epinotum distinctly shorter than the declivity, the two, meeting in a very definite angle; at the point of their junction there is a deep median furrow which extends throughout most of the base of the epinotum. Distal end of the tibia of each leg with a single, well defined spur. Petiole with the anterior surface decidedly declivous, on each side, the declivous surface more or less bounded by a lateral border which terminates antero-ventrally in a small, blunt tooth or tubercle; superior margin entire, rounded from side to side, and rather abruptly meeting the very short and somewhat vertical posterior surface; ventral surface with a lamellar plate, which is backwardly directed. Gaster oblong, the apex reflexed but not quite so strongly as with the worker or female; the first segment truncate at base, meeting the second segment in a very strong constriction; the second segment large, easily occupying more than one half of that portion of the dorsum which is visible from above; genitalia capable of being extruded or retracted.

Mandibles, clypeus, frontal area, scapes of antennæ, anterior surface of petiole, legs, and gaster smooth and shining; remainder of body subopaque. Head, thorax, and petiole, rugulose-reticulate; the sculpturing on the head somewhat fine, that on the thorax heavier, especially on the pleuræ of the prothorax, and on the epinotum; petiole also similarly sculptured.

Pilosity golden yellowish; suberect? moderately dense, covering all parts of the body. Pubescence of the same color as the pilosity, dense, covering all parts of the body, but less abundant and less conspicuous on the pleuræ of the thorax; in some lights the pile and pubescence give the body a burnish golden tinge.

Ferruginous; head, dorsum of thorax, petiole and gaster infuscated.

Described from three alate males, which, with a large number of alate females, and workers were collected from several cavities in a rotting pine log, 4 miles north of Aberdeen, Mississippi, on August 19, 1929.

Cotypes are in the collection of the Department of Entomology of the Mississippi A. & M. College, and my collection.

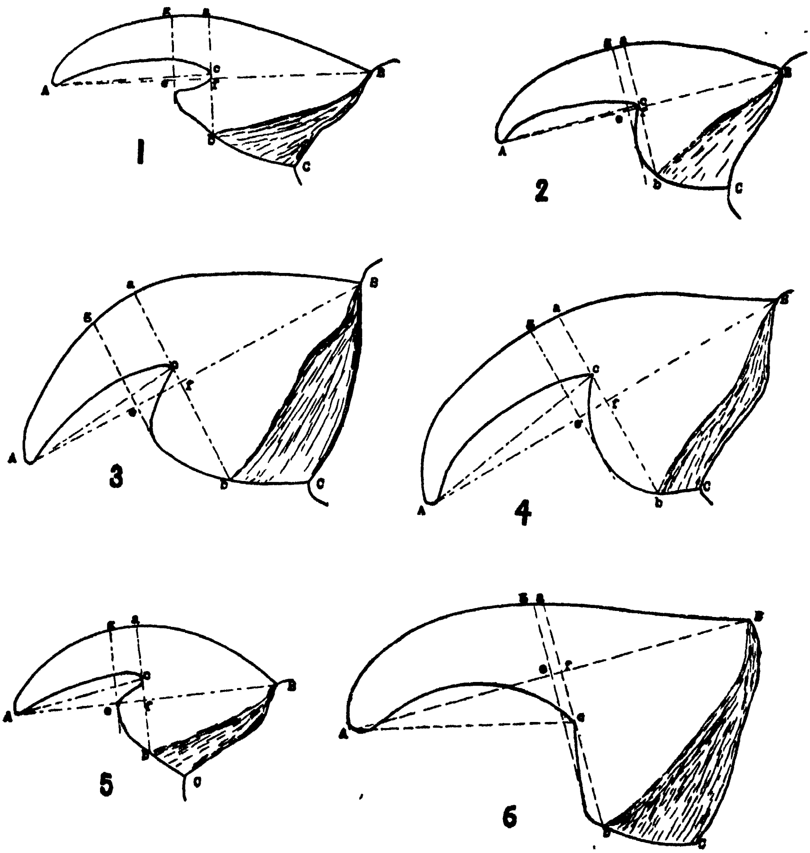
TARSAL CLAWS OF NOCTUID LARVÆ.

J. H. HAWKINS,
Agricultural Experiment Station, Orono, Maine.

All species of noctuid larvæ have many characteristics in common and certain closely related forms are similar even to minute structural detail. Species of different genera are sometimes so much alike that they can scarcely be identified in the larval stage. Taken as a whole the group offers serious difficulties for the taxonomist and it has been found necessary to rear some species to the adult stage in order to identify them. Natural colors of these caterpillars are sometimes specific, but unfortunately color patterns of preserved specimens are not always reliable. At the present time no single character is known which is variable with the species sufficiently to be of use in the taxonomy of the whole family. A comparative study of many details of form and structure is a prerequisite of the identification of certain species of noctuid larvæ. Consequently any character which is constant in form within a species and variable within the family may serve as an aid to the identification of unknown specimens. Tarsal claws of noctuid larvæ are fairly constant for the species and are commonly of different forms and proportions in different species.

Before explaining methods of comparison a general description of a typical tarsal claw may be helpful. The broad base of the claw is attached to the distal extremity of the tarsal segment by a whitish, flexible membrane which forms a triangle on the lateral aspect of the claw. The two sides of the triangle are the base and the ventral margin of the claw respectively and the hypotenuse is the line separating the membrane from the sclerotized distal portion. (Fig. 1, BCb.) A somewhat tapering hook, curved in a ventrad direction, extends distally from the dorsal portion of the base and a convex angulate process, much shorter than the hook is produced distally from the ventral portion of the base and for convenience in this paper is termed the sole. Occasionally the sole may be only a flattened surface projecting but little or even receding towards the base. (Fig. 6.) That there are variations in the length,

shape and curvature of the hooks is shown in a comparison of the claws of *Euxoa messoria* Harr. and *Agrotis unicolor* Walk. (Figs. 1 and 2.) The claw of the hook of *E. messoria* is proportionally narrower at its base, slightly less curved and less tapering than that of *A. unicolor.* However, the greatest



TARSAL CLAWS OF NOCTUID LARVAE.

Fig. 1. *Euxoa messoria* Harris.
Fig. 2. *Agrotis unicolor* Walk.
Fig. 3. *Agrotis c-nigrum* L.
Fig. 4. *Cirphis unipuncta* Haw.
Fig. 5. *Polia meditata* Grote.
Fig. 6. *Nephalodes emmedonia* Cram.

difference between the claws of these two species lies not in their hooks but in their soles. The sole of *E. messoria* is an angular process while that of *A. unicolor* is merely a rounding of the distal margin of this region. These two species bear claws which are so different that a simple comparison is sufficient

for one to distinguish them from each other. In other species the differences are less obvious and it is necessary to make careful measurements and comparisons, if they are to be disclosed. Figures 3, 4, 5 and 6 illustrate other forms of tarsal claws of this group of larvæ.

It is sometimes desirable to establish differences of a minute character in the study of tarsal claws. In order to demonstrate such differences, enlarged photographs can be made by using a photomicrographic camera. These photographs can then be reversed, their outlines traced, and lines drawn as follows: AB is drawn from the distal extremity of the hook to the dorsal margin of the claw at the point of junction with the tarsus (Fig. 1); ab is drawn perpendicular to the line AB through the point of junction of the hook and the sole. The ratio of the length of the line AB to the length of the line ab represents the ratio of the straight line length of the sclerotized portion of the claw to the transverse dimension; the line ab striking the margin of the claw at or near the proximal limits of sclerotization. Decrease in the length of the line AB in proportion to the length of ab is usually associated with a corresponding increase in curvature of the hook. The line eg is drawn parallel to ab through the most distal point on the margin of the sole and the line ef represents approximately the distal limits of the curve or angle, as the case may be. The line ab striking the ventral margin at the point b, marks approximately the distal limits of the membraneous portion of the claw and represents the approximate width of the distal curve. Ac is a chord connecting the extreme limits of the ventral curve of the hook and represents the straight line length of that part of the claw.

Ratios obtained by dividing the unit length of various lines, representing different parts of the tarsal claw as described above, have been found useful in obviating the necessity of having all claws to be compared photographed at the same magnification. They should be photographed from the same angle however, and it is better to use the claws from corresponding legs of larvæ being compared. Claws can be transferred from 95 per cent alcohol to carbo xylol and after clearing can be mounted on slides in balsam. They can be manipulated in the balsam with a needle wet in carbo xylol and should be mounted flat on the slide so that all the mounts to be compared present the same lateral aspect.

Claws of several species of noctuid larvæ have been measured and the ratios are presented in the accompanying table. The ratios are as follows: AB to Ac the length of the sclerotized portion of the claw to the length of the hook, both being straight line lengths; ab to ac the width of the claw to the width of the hook at its base; ab to cb the width of the claw to the width of the sole; and cb to ef represents the ratio of the width of the sole to its altitude.

TABLE OF RATIOS.

PARTS OF TARSAL CLAWS.

	AB : Ac	ab : ac	ab : cb	cb : ef
Euxoa messoria Harr . . .	2 00	2.00	2.00	1.58
Euxoa tessellata Harr.	2 56	1.50	3.00	2.75
Euxoa ochrogaster Guen . . .	2 03	1.90	2.11	3.80
Feltia gladiaria Morr.	2.25	2.09	1.91	3.50
Feltia ducens Walk.	1.90	1.15	1.42	2.87
Feltia herilis Grt.	2 28	1.80	2.45	2.25
Feltia volubilis Harv.	2.13	2.04	1.95	3.63
Feltia annexa Treit.	2.66	2 27	1.79	2.33
Feltia malefida Guen.	2.19	2 18	1.84	3.12
Agrotis ypsilon Rott.	1.97	2.00	2.00	5.00
Agrotis c-nigrum L.	2.15	1.53	1.65	2.35
Agrotis bicarnea Guen. . . .	2.11	2.25	1.80	5.00
Agrotis normaniana Grt . . .	2.05	2.63	1.92	5.55
Agrotis phyllophora Grt . . .	1 97	2.21	1.82	5 11
Agrotis fennica Tausch. . . .	2 09	2.05	1.95	2.22
Agrotis unicolor Wlk.	2.04	2.15	1.86	7.33
Lycophotia occulata L.	2.06	2.01	1.90	5.50
Lycophotia margaritosa Haw.	2.18	2.52	1.68	4.83
Lampra brunneicollis Grt. . .	2 20	2.04	1.83	8.00
Polia imbrifera Guen.	1 80	3.43	1.41	3.66
Polia meditata Grt.	2.29	2.15	1.56	2.85
Polia legitima Grt.	1.76	2.05	1.91	2.12
Polia renigera Steph.	2.04	2.52	1.65	2.66
Nephalodes emmedonia Cram.	1.73	1.75	2.33	7.50

PROFESSOR HERBERT OSBORN

EDITOR EMERITUS

ANNALS

OF

The Entomological Society of America

Volume XXIII SEPTEMBER, 1930 Number 3

PROFESSOR HERBERT OSBORN

EDITOR EMERITUS.

The Editorial Board of the Annals of the Entomological Society of America, as representative of the sentiment of the Society, wishes in this manner to express the Society's appreciation of the long years of service of Professor Osborn as Managing Editor of the Annals. It is fitting at this time to present a portrait and a brief sketch of the Editor Emeritus to whom the present editorial policies, the form and quality of the Annals from its inception to the present are largely due.

Professor Osborn was born at Lafayette, Wis., March 19, 1856. He graduated at Iowa State College in 1879 and from this date to 1898 was engaged in zoological and entomological work at Ames. From his Alma Mater he received the degree of M. S. in 1880 and that of Sc. D. in 1916. He was Professor and Head of the Department of Zoology and Entomology from 1885 to 1898. From 1898 to 1916 he was Head of the Department of Zoology and Entomology at Ohio State University and since 1916 Research Professor.

Besides developing the work in Entomology at Ohio State University, he was especially interested in the development of the Ohio State University Lake Laboratory, of which he was Director from 1898 to 1918, and in the development of the Ohio Biological Survey, of which he has been Director since 1912. He was State Entomologist of Iowa in 1898, President of the Iowa Academy of Science in 1887, President of the American Association of Economic Entomologists in 1898, President of the Ohio Academy of Science in 1904, President of the American Microscopical Society in 1907–09, President of the Entomological Society of America in 1911, President of the Society for the Promotion of Agricultural Science in 1917-18, and Vice-President (Chairman of Section F.) of the American Association for the Advancement of Science in 1917.

On examining Professor Osborn's bibliography as compiled in the University records we find that his major interests have been along two lines, one in general economic entomology and the other in the systematics and biology of the hemipteroid insects. These papers

make a total of nearly three hundred items. Along with these has been a steady output of papers in agricultural and popular journals which have helped to show the value of economic entomology to the general public. The latter series totals two hundred and fifty papers. His first scientific article appeared in 1879, then followed a series of one hundred and fifty papers on various insect pests which increased in frequency until about 1900, since which time papers on the Hemiptera have largely displaced them, a series which now approaches one hundred items. Some lesser interests appear. In 1883 he published his first article on parasites of domestic animals which started a series of twenty papers that reached its peak in the classical bulletin, "Insects Affecting Domestic Animals." Another interest is found in the series of articles on Thysanoptera, while a third interest is one on insects affecting pasture and grass-lands. Professor Osborn was the first to show the great damage done to meadows and forage by such inconspicuous insects as leafhoppers and other minute Hemipteroids. As Research Professor he has just published in the "Leafhoppers of Ohio" the results of thirty years of collecting in the State and is at present working largely on Neotropic leafhoppers.

Professor Osborn has never approached any phase of his work except with a profound respect for its importance. It is probably this attitude more than any other thing, except perhaps his example of unremitting work, that has inspired so many of his students Even vacations have been crowded with either economic entomology or the collecting of more Hemiptera.

Professor Osborn's greatest contribution to Science in general and to Entomology in particular is in the body of graduate students who acquired from him their enthusiasm for the science to which he is devoting his life.

An appreciation from the Society is especially fitting at this time as it marks the rounding out of fifty years of scientific labor which has given him his present eminence in Science and Education. In the same spirit was the testimonial dinner given in his honor on December 17, 1929, by his colleagues and students and the degree of Doctor of Laws conferred on him by the University of Pittsburgh, February 10, 1930, both honors in memory of his long service to Science.

THE MOUTH-PARTS OF THE LARVAL AND ADULT STAGES OF DERMESTES VULPINUS F.*

VERNA E. ROBINSON,
St. Paul, Minn.

INTRODUCTION.

The cosmopolitan species, *Dermestes vulpinus* Fabricius has long been considered an insect of economic importance. At one time it committed such ravages upon furs of the Hudson's Bay Company in its storehouses in London that a reward of 200,000 Pounds was offered for a means of effectually destroying it (Lintner, 1884). Since that time it has been reported destroying hides and leather in many different countries. Distant (1877) told of a cargo of dried hides received in London from China which had suffered damage from its ravages as great as 15 to 20 percent of the value. Jones (1889) gave an account of the hide beetle found at work in goat skins from Russia, Arabia, Mexico, Turkey, and Cape Town, South Africa. Its activities are well known in the tanneries and shoe factories of our own country (Riley, 1886), (Lintner, 1887). Illingworth (1918) stated that *D. vulpinus* F. was the principal cause of injury to the dried fish in Honolulu. Kimura and Takakura (1919) reported its ravages of the dried fish in Japan. As early as 1837 it was recorded as destroying a cargo of cork brought to England from Brazil (Bowerbank, 1837). Holland (1896) reported a loss of 2 percent of a shipment of cork from Spain, due to its ravages. Snyder (1920) described "one of the most serious cases of direct injury to metal by insects—that by *D vulpinus* F. to tubular lead telephone fuses." The insect eats through the lead (alloy) tape of the fuses. It has also earned the title of "bone beetle" from its frequent infestations of bones wherever they are stored in large quantities. They feed on the dirty bones and then bore into the framework of the storage buildings to pupate. Walker (1884) reported a case at Queensborough, England, where the wooden framework

*Contribution from the Zoological Laboratories of the University of Minnesota.

of a storage room in a bone-boiling works was destroyed by their honey-combing activities. Potter (1898) reported similar ravages in New Zealand. The hide beetle was found in great numbers in the hoof-drying room and the bone-fertilizer store rooms of a packing plant in St. Paul, Minnesota, where the larvæ have honey-combed areas in the wooden framework as large as a foot square and one to two inches deep.

Little has been done on the anatomy of this important species. Riley (1886) described the mouth parts and external characteristics of the larvæ briefly. Kreyenberg (1928) described the larval mouth parts and the digestive systems of this species and *Dermestes lardarius* Linneaus. Since only these two brief papers have been found which describe the mouth parts of the larva of the hide beetle and because there is comparatively little information available on the mouth parts of Coleopterous larvæ and adults, special stress has been laid on the mouth parts of the larva and adult of *D. vulpinus* F. in this paper.

METHODS AND MATERIALS.

Fresh material was used for all of the dissections. Permanent mounts were made for the study of the mouth parts. In some cases the structures were mounted in Buxton's fluid (Buxton, 1921) as soon as they were dissected from the fresh specimens. In other cases they were dehydrated, cleared in xylol, and then mounted in balsam. It was found beneficial to use haematoxylin and acid fuchsin in studying the finer details of the larval labrum and and the adult labium.

THE MOUTH PARTS.

Unfortunately there is, at present, a great deal of variation in the nomenclature used in the study of insect anatomy. This is especially true in the study of the mouth parts for which the morphologists, embryologists, and systematists all have different names. In the absence of the much-to-be-desired standard nomenclature for the mouth parts, that presented by MacGillivray (1923) in the "External Insect-Anatomy" has been used in this paper.

A. *Larval Mouth Parts.*

The labrum (Plate I, Fig. 3) is saddle-shaped and a little less than twice as large as that of the adult. Its depth is in proportion to its width as 1 : 3. Somewhat convex, but not as much so as the adult labrum, it is less heavily sclerotized and bears fewer setæ scattered over its dorsal surface. A few setæ are longer than the depth of the labrum, but the rest are short, all are pointed. There are two small, heavily sclerotized areas (cha) on either side of the center of the labrum just back of the emargination of the distal margin. These areas are, apparently, the bases to which the curved, sclerotic tooth-like processes of the underlying epipharynx (Fig. 6, tlp) arc attached. There are four pointed setæ around the emargination which project disto-mesad. Besides these setæ, there are other hair-like projections (meh, lah) which lie along the distal margin covering most of it. The number of these varies among individuals from 45 to 60. These processes have a peculiar form (Fig. 4). They consist of three definite parts. The first is a conical projection (conp), an integral part of the labrum, which arises a slight distance from the margin. This projection is blunt at the tip bearing a nipple-like process medially which fits into the concave, cup-like base (ps) of the second part, the proximal segment, which is the first articulating part of the structure. The membranous distal segment (ds) is attached to the basal segment which extends to the margin of the labrum.

The five mesal structures (Fig. 3, meh) on either side of the center are markedly different from the others, and these five are not all alike. The most mesal two (Fig. 4, A) have a very short, bluntly pointed, uncurved, distal segment, while the other three have longer ones which curve sharply ventro-mesad over the labral margin. The lateral processes (lah) are more slender having abruptly but sharply pointed apices to their distal segments which all project disto-mesad. The more mesal of these are longer and broader, while the more lateral ones become progressively smaller and shorter. Kreyenberg (1928) studied the labrums of *D. lardarius* L. and *D. vulpinus* F., but figured only that of the former, saying the two were very similar. Specimens of both species have been studied by the author in an effort to verify his description. His figures shows the hair-like processes as being formed of three definite segments, but the specimens studied in this work did not verify this. In both cases the hair-like processes were observed to consist of only two definite segments, each process articulating with a conical base which is an integral part of the labrum. These processes are much more pointed and are more variable in number in *D. vulpinus* F. than in *D. lardarius* L. In the former, as mentioned above, they may vary from 45 to 60, while in the latter they vary only from 46 to 50. In the former, there is rarely an equal number of processes on both sides of the labrum, usually there are 2 or 3 more on one side than on the other; in the latter, however, there are usually the same number on each side of the labrum as described

by Kreyenberg. Roberts (1926) described structures of the labrum of the larvæ of *Phyllobius urticæ* DeGreer and *Phyllobius pyri* Linneaus that are, apparently, similar to the jointed, hair-like processes described above. He said the labrum is "provided on the anterior margin with 8 down-curving setæ in pairs, in addition to a pair of shorter much-curved setæ, situated one on either side of the median pair. All these arise on the dorsal surface." His descriptions and drawings do not give definite information regarding the basal structure of these setæ, but they seem to indicate a two-segmented condition in the lateral setæ, at least. These lateral structures are all more bluntly rounded at the apex than those of the *Dermestes*. There are 18 present here, compared to the 45 to 60 found in the *Dermestes* labrum; but he shows long lateral, and shorter median setæ which all curve downward and mesad, as do the structures on the *Dermestes* labrum. The sclerite-like structures that Kreyenberg figured within the labrum of *D. lardarius* L. were not found in the labrum of either species. The long, pointed, tooth-like projections that he figured extending proximad from the margin of the labrum are structures belonging to the epipharynx, as shown in Fig. 6, tlp. This is the case in both species.

The mandibles (Plate I, Fig. 1, 2) are nearly hidden by the labrum. They are broad, thick, pyramidal structures with their length, width and depth in the proportion of 3 : 2 : 1. They are heavily sclerotized and of a reddish brown color. Their sharp, cutting, inner margin bears three teeth, the blunt proxadentis (pd) and the more pointed mid-dentis (dd) and distadentis (md), (Kreyenberg, 1928), (Riley, 1886). Since they are convex on their dorsal surface and concave on their ventral surface, they are easily overlapped. In their normal position, one mandible overlaps the other; in some individuals it is the left and in some it is the right one. The lateral or exposed narrow triangular surface of the mandible forms a shallow groove or furrow called the scrobe (sb). A row of large setæ arise in this furrow. A tuft of longer hairs arises on the lateral surface and around the base of the scrobe. Two distinct projections are noted on the proximal half of the inner margin of the larval mandible. The more distal one (WZ) is a smooth, membranous finger-like structure which projects inward and proximad. Kreyenberg (1928) figures and describes this structure and calls it "Weichhautiger Zapfen." The other process (pc) consists of a small, broad, membranous lobe, the apex of which lies ventral to the inner lateral edge. This lobe bears many long setæ which stand so close together that they look like a tiny, long-haired brush. Kreyenberg does not figure or describe this structure. It corresponds to the description given by MacGillivray for the structure which he calls the "prostheca." Hollis (1872) presents an interesting homology between the prostheca and the mandibular palpi of the isopods and crustaceans. The prostheca is more prominent in the mandibles of *D. vulpinus* F. than in those of the mandibulate insects which he compares with the isopod and crustacean structures. The mandibles have two prominent points of articulation with the tentorium and the head capsule; the

preartis and the postartis. The large preartis (pre), situated in the outer half of the proximal margin of the dorsal surface, is a prominent hemispherical cavity. The prominent postartis (ptc) is situated between the lateral and ventral aspects and is divided into two parts; the large spherical condyle which projects conspicuously from the concave ventral surface, and the smaller, lateral condyle lying on the proximal margin of the scrobe. This part of the postartis is not of spherical shape, but appears as a projecting shoulder extending over the margin of the mandible.

The maxillæ (Plate I, Fig. 5) are located under the large mandibles which cover them dorsad. They are complex structures whose width is in proportion to their length as 1 : 4. The weakly sclerotized basal segment, the cardo, is divided in the larval maxilla. The proximal sclerite, the subcardo (sa), is subquadrangular in shape. The parartis, the swelling located at the proximal end of the subcardo, is bifurcate in this form, having the exparartis (ey), a spherical swelling articulating on the external face of the paracoila, and the entoparartis (en) of the same shape but smaller articulating on the internal surface of the paracoila. The distal sclerite, the alacardo (al), is subtriangular in shape. It is located along the lateral margin of the subcardo and is separated from it by a longitudinal suture. It is articulated at its distal end with the stipes. This sclerite bears a few small setæ. The subquadrangular stipes (s) composes the largest sclerite of the maxilla. It is weakly sclerotized as a whole, although it bears two heavily sclerotized margins where it articulates with the subgalea and the palpifer. There are a few setæ scattered over the stipes. The distal part of the stipes is greatly elongated mesad. This arm bears the lacinia. The subgalea (sg) in the larval maxilla lies along the mesal margin of the stipes. It is not well developed, being small and very weakly sclerotized. The disto-lateral margin of the stipes bears the palpifer (pf). The proximal part of this structure is membranous, but a sclerotic band is present on the dorsal aspect of the distal end. The palpifer bears a few setæ. A three-segmented palpus (mp) is borne by the palpifer. The third segment has a rounded, membranous tip bearing a number of conical setæ (cs) which are probably tactile organs. The second segment, only, bears a few setæ. The galea (gl) of the larval maxilla consists of a rather large, membranous lobe which has a small sclerotized area on the inner surface toward the distal end. It is attached to the membranous base of the palpifer. The rounded, distal end of the galea is covered by a thick crown of blunt setæ and spines, the galarastra (gls). The lacinia (la) borne by the projecting arm of the stipes consists of two parts. A membranous lobe bearing a dense crown of blunt setæ, the lacinarastra (lac), lies on the dorsal aspect. A bidentate sclerotic structure, the maxadentes (ms), forms the ventral surface. The lacinia of the larval maxilla of *D. vulpinus* F. examined possesses a distinctly bidentate sclerotic hook on the distal end. Kreyenberg (1928) figured and described the larval maxilla of *D. lardarius* L. and, as in the case of the labrum, said that it was

very similar to the maxilla of *D. vulpinus* F. The maxillæ of both species were studied in this work. Kreyenberg's description of the maxilla of *D. lardarius* L. was verified, but the maxilla of *D. vulpinus* F. was found to differ from it in several points. The cardo in *D. vulpinus* F. is divided by a more definite suture whose margins are more heavily sclerotized; the parartis of this species is clearly distinguished as a bifurcate structure but is only weakly sclerotized in the other; there is a heavily sclerotized band along the mesal margin of the stipes of this species but only a very weakly sclerotized band along that margin in the maxilla of *D. lardarius* L. The subgalea is present as a definite sclerite in both species. Kreyenberg did not describe or name this sclerite, although he figured it in his drawing. In both species the galea is attached to the palpifer as Kreyenberg figures it in *D. lardarius* L.

The masticatory structures of the pharynx are located in the prepharynx (Plate I, Fig. 6), the cephalic portion of the pharynx located adjacent to the mouth. The structures in the larval prepharynx are quite generalized. The dorsal portion of the prepharynx, the propharynx (pex), consists of two distinct regions, the epipharynx (ex) and the epigusta (eg). The epipharynx forms the ventral wall of the labrum In the larva it is the same size and shape as the labrum. Its caudal extent is limited by the tormæ (tor) at the lateral ends of the clypeo-labral suture The membranous epipharynx bears two prominent, tooth-like, sclerotic processes (tlp) in the mesal region near the cephalic margin. These processes are attached at their bases to the corresponding, heavily sclerotized areas in the labrum (Fig. 3, cha). As mentioned above, Kreyenberg (1928) shows these sclerotic tooth-like processes as belonging to the labrum of *D. lardarius* L. The labrum and epipharynx of both this species and *D. vulpinus* F. were examined in this work and these sclerotic tooth-like processes were found to be definitely a part of the epipharynx in both species. The literature describes sclerotic structures of various shapes in this region of the epipharynx of several Coleopterous larvæ. Carpenter and MacDowell (1912) described two small, stout teeth in the anterior region to the left of the mid-line in the asymmetrical labrum of *Dascillus cervinus* Linneaus. Boving (1921) described four sclerotic plates in the mesal part of the anterior region of the epipharynx of *Popillia japonica* Newman. Roberts (1926) mentions two strongly sclerotized arms of the epipharynx which reach nearly to the anterior margin of the labrum in the larvæ of *Phyllobius urticæ* DeGeer. About a dozen tiny, cup-like depressions (tac) lie caudad of these processes in the mesal region. In the larva these tiny structures are arranged approximately in two rows, the more caudal being noticeably smaller than the other. These tiny depressions correspond in their structure and location in the epipharynx to those described by Packard (1889) which he calls taste-cups. There are no setæ or hooked hairs near these depressions for the epipharynx is entirely bare except for the two large tooth-like processes. The epigusta (eg) is located caudad of the epipharynx. Its caudal extent is limited by the transverse mandoris (mdo). In

the larva, the epigusta bears two sclerotized rods, the epipharyngeal rods (exr), laterad. The ventral portion of the prepharynx, the parapharynx (prx), consists in the larva of two regions, the subgusta, and the hypopharynx. The membranous subgusta (su) is the most caudal region for it borders on the mandoris. On the lateral boundaries of the subgusta, there are two prominent sclerites which are opposite the epipharyngeal rods in their caudal regions at the sides of the mandoris. These sclerites, the pharyngea-lingula (prg-ln), are formed by the fusion of three sclerites, the pharyngea, the paralingua, and the lingula. The distal, tongue-like portion, the hypopharynx (hx), is slightly convex in the larva. A prominent supporting sclerite lies in the membranous hypopharynx a little distad from the pharyngea-lingula. This convex sclerite (sl) represents the fused salivias. It is not articulated with the pharyngea-lingular, but lies isolated in the membranous structure. The mouth or the salivos (so) of the salivary duct (sld) which lies underneath the hypopharynx, is located at the distal end of the hypopharynx which is fused with the paraglossæ (Snodgrass, 1928). There is no definite suture here between the paraglossæ and the hypopharynx like that found by Carpenter and MacDowell (1912) in *Geotrupes* sp. No maxillulæ are present.

The labium (Plate I, Fig. 7, 8) lies on the ventral aspect of the head between the maxillæ. It is a prominent, though weakly sclerotized, structure in the larva. Its width is in proportion to its length as 1 : 2.5. The subquadrangular sclerite (sm-gu) formed by the fusion of the submentum and gula composes the proximal part of the labium. It bears a few setæ on its ventral aspect. This sclerite is separated from the large mentum (m) by a narrow, membranous fold which marks the line of attachment of the cardos. The prominent mentum attached to the distal end of the submentum-gula is divided into three parts; a central quadrangular section and two arm-like lateral sections, by narrow membranous areas between the central and lateral parts (Fig. 7, m). These narrow membranous areas function as hinges upon which the lateral sections fold dorsad. The weakly sclerotized central section extends distad to a delicate suture which separates it from the stipulæ. In general, the sclerotization in this region extends only to this dividing suture, but it may pass distad a short distance into the membranous stipulæ. The lateral sections of the mentum are more heavily sclerotized and bear a row of setæ along their mesal margins. The delicate suture marking the proximal margin of the stipulæ, definitely present in the mesal part of the lateral sections, becomes obsolete in the lateral regions where the mentum fuses with the sclerotic lateral regions of the stipulæ. Here the distal end of the mentum is indicated only by the attachment of the distal end of the labacoria (lc). The stipulæ (sp), distad of the mentum, is divided into halves by a delicate mesal suture (Fig. 7). The stipulæ are also divided into proximal and distal regions by a distinct suture which extends across the mesal regions, becoming obsolete laterad (Fig. 7, 8). The stipulæ are membranous save in the lateral and disto-lateral regions,

where they are heavily sclerotized. Laterad the stipulæ bear the palpigers (pp). A few small setæ arise in the weakly sclerotized, proximal region of the palpigers, while the distal membranous half is bare. The weakly sclerotized two-segmented labial palpi (lp) arise from the palpigers. The distal segment of the palpi terminates in a rounded membranous apex, which bears a few conical setæ (cs). Riley (1886) and Kreyenberg (1928) described three-segmented labial palpi in *D. vulpinus* F , but the segment they count as the basal segment is here shown to be the palpiger (pp), a fixed part of the labium which bears the mobile two-segmented palpi. The membranous paraglossæ, separated from the stipulæ in the mesal region by a distinct transverse suture, extend on to the dorsal surface of the labium and fuse with the disto-lateral arms of the stipulæ laterad to the palpigers (Fig. 8, pgo, sp). The glossæ are wanting and the adjacent paraglossæ are separated by a distinct alarima (ala). Dorsad, the paraglossæ, which are covered with tiny spinules, are fused with the distal margin of the bare hypopharynx save in the region adjacent to the salivos (Fig. 6, pgo, hx, so).

B. *Adult Mouth Parts.*

The labrum (Plate II, Fig. 2) of the adult is about one half the size of the larval structure. Its width is in proportion to its depth as 4 : 1. This broadly rounded, convex flap, having a distinct emargination at the middle of its cephalic margin, is attached to the distal margin of the clypeus. Numerous large setæ are borne over the surface of the labrum and around its cephalic margin. Smaller setæ are scattered among the larger ones.

The adult mandibles (Plate II, Fig. 1, 3) are two thirds the size of those of the larva and have the same general shape. They are, however, more definitely pyramidal, having a well defined lateral face which appears as a continuation of the lateral aspect of the head. The dorsal aspect of the mandibles is convex, the ventral concave, and the lateral triangular and concave, forming a distinct scrobe. The scrobe (sb) is comparatively larger in the adult mandibles and bears many more setæ. The margins are all more sharply defined and the whole structure is more strongly sclerotized than in the larval mandibles. The mesal and distal margins are provided with tooth-like projections as in the larva, but here the distadentis (dd) is more prominent, being long, curved and rather sharply pointed. There is no projection corresponding to the middentis on the larval mandible, and the innermost, the proxadentis (pd) is shorter and more blunt. There is no structure corresponding to the "Weichhautiger Zapfen" of the larval mandible here, but there is a dense area of long setæ adjacent to the mesal margin known as the suprabrustia (spr) which lies in a position similar to that of the "Weichhautiger Zapfen." The prostheca (pc) is prominent on the adult mandible. Here the submembranous lobe is so elongated that it extends beyond the inner margin of the mandible. With its brush of long setæ and spinulæ projecting meso-proximad it forms a conspicuous structure. The preartis (pre) is clearly defined in

the outer part of the proximal end of the dorsal aspect of the mandible. It is concave here, too, but more shallow than in the larval mandible. The postartis (ptc) is located between the lateral and ventral aspects of the mandible and is divided into two ball-like condyles arising from the scrobe and the ventral aspect respectively.

The maxillæ (Plate II, Figs. 6, 8) of the adult are only half as long as those of the larva. Their width is in proportion to their length as about 1 : 2.5. They are heavily sclerotized and the sclerites are more clearly defined than those in the larval maxillæ. The subtriangular cardo (ca) is not divided here. It is quite heavily sclerotized and bears numerous setæ. The parartis (par) is visible on the dorsal aspect. The broad stipes (s) is subtriangular in form on the ventral aspect and subquadrangular on the dorsal surface. The broad base articulates with the latero-distal margin of the cardo. This sclerite is not heavily sclerotized, but it bears numerous setæ on its ventral aspect. The palpifer (pf) is attached to the disto-lateral angle of the stipes. This sclerite is only heavily sclerotized along the lateral surface where it bears a few large setæ. It is subtriangular in form. Two structures are articulated on its distal margin, the galea (pg) from the ventral aspect and the maxillary palpus (mp) from the dorsal. The palpi (mp) consist of four segments of unequal size, the first short, the second rather long and curved distally, the third short and barrel-shaped, and the last, long and conical, bearing numerous, conical setæ (cs) on its rounded distal end. The basal half, only, of the first three segments is heavily sclerotized while all of the terminal segment except the membranous, sensory tip is sclerotized. Each of the three basal palpal segments bears a ring of setæ on the distal margin of their sclerotic bands but the distal segment only bears a few along its lateral surface. The two-segmented galea arises from the ventral aspect of the palpifer in this form rather than from the stipes. Its proximal segment, the proxagalea (pg), is rather conical in shape with the apex articulating with the palpifer. It is heavily sclerotized, but bare. The distal segment, the distagalea (dg), is a soft, membranous lobe which bears a dense crown of setæ, the galarastra (gls). The subgalea (sg) articulates with the mesal margin of the stipes. This subquadrangular sclerite bears no setæ, but is sparsely punctate on both the ventral and dorsal aspects. A heavily sclerotized band passes along the lateral margin of the ventral aspect from its base to the proximal end, where it marks the articulation of the lacinia with the subgalea. The lacinia consists of two parts. A long, slightly curved hook (dh) which projects proximad, lies on the ventral aspect. The second part, lying on the dorsal aspect, is a large membranous lobe with a dense covering and crown of setæ, possibly comparable to the lacinarastra (lac).

The prepharyngeal structures of the adult differ in many points from those of the larva. The adult propharynx is subquadrangular in shape rather than subtriangular. Arising from the distal and lateral margins of the labrum, the membranous epipharynx (Plate II, Fig. 4, 5, ex_1, ex) extends outward, then bends back upon itself abruptly, forming a thin, membranous rim around the edge of the labrum (lab) as well as its

ventral lining. There is a marked difference in the size and arrangement of the setæ on the different parts of the epipharynx. That part (ex_1) which forms the dorsal surface bears two or three rows of prominent setæ along and near the lateral margins. In the mesal region there is a pilose area of short, spiny setæ surrounding the emargition. The most distal of these setæ, which are the longest in this area, are about the same size as those along the lateral margins. There is a small region, distad to the labral margin and proximad from this pilose area, which is bare. That part of the epipharynx (Fig. 7, ex), which forms the real lining of the labrum, possesses two delicate columns of short setæ lying on either side of the mid-line. These meso-distad projecting setæ, which are a little larger and more numerous near the margin, decrease in number and size caudad until, in the proximal region of the epipharynx, there are only two or three on either side of the sensory cups. These sensory structures (tac) are similar in structure and position to those of the larva, but they are a little more numerous in the adult, and all are of the same size. Packard (1889) describes a similar epipharynx for *Telephorus rotundicollis* Say as extending quite far in front of the labrum, forming a thin, pale, membranous, pilose edge and not provided with taste cups. Van Zwaluwenburg (1922) describes and figures a similar structure for *Melanotus fissilis* Say. In both of the cases cited, however, the epipharynx extends beyond only the distal margin distinctly, while in *D. vulpinus* F. it extends beyond both the lateral and distal margins of the labrum very definitely (Fig. 4). The epigusta (Fig. 7, eg) in the adult propharynx differs in shape from that of the larva It is larger and is subquadrangular for it tapers very slightly in the region of the mandoris. The mandoris (mdo) itself is about the same size as in the larva, but the sclerites bounding it are conspicuously larger. The epipharyngeal rods (exr) lie along the lateral margins of the epigusta. These weakly-sclerotized structures arise as delicate and narrow sclerites at the tormæ (tor), but broaden caudad until, at the mandoris, they occupy two-thirds of the breadth of the propharynx.

The adult parapharynx (prx) differs from that of the larva in several respects. The supporting skeletal structure (Fig. 9, prg-ln, sl) lies ventrad to the membranous subgusta and hypopharynx while in the larva the pharyngea-lingula and salivias (Plate I, Fig. 6, prg-ln, sl) lie imbedded in these membranous structures. All of the supporting sclerites are fused in the adult; the salivias being fused with the pharyngea-lingula on either side, while their cephalic ends are produced and fused on the meson, forming a broad sclerotic band projecting ventrad (Plate II, Fig. 9, sl). This somewhat horse-shoe shaped structure articulates with the epipharyngeal rods on either side of the mandoris (Fig. 7, mdo, exr). The convex, membranous subgusta (su) arises on the dorsal side of the fused pharyngea-lingula-salivias along this line of articulation and on the ventral side of the mandoris. The subgusta is densely covered with short spiny setæ which point sharply caudad. In the adult, the membranous paraglossæ (pgo) are fused dorsad on the meson and fused with the distal margin of the hypopharynx. These

prominent structures extend proximad or caudad on either side of the hypopharynx to fuse with the distal margin of the subgusta. In the larva, the paraglossæ (Plate I, Fig. 6, pgo) are not fused distad, and they extend only a short distance latero-proximad. The proximal margin of the adult hypopharynx (Plate II, Fig. 7, hx) is fused to the distal margin of the subgusta between the paraglossæ. There is no distinct suture marking the fusion of the membranous, slightly convex hypopharynx with the subgusta and the paraglossæ. It is readily distinguished from them, however, because it is naked while they bear numerous setæ. There is no salivos present at the distal end of the hypopharynx as there is in the larva.

The labium of the adult is a very complex structure compared to that of the larva. The gula and submentum, the conspicuous structures exposed on the ventral aspect, are strongly sclerotized. The slender gula (Fig. 10, gu) extending from the foramen to the submentum is separated from the latter by the mentasuture (msu). The gula is nearly twice as long as the submentum, about the same in width in its proximal and distal regions, but much more narrow in the middle. This sclerite is slightly convex laterad and bears numerous small setæ on its ventral surface. The prominent submentum is somewhat shield-shaped being distinctly convex laterad and slightly convex proximad (Fig. 9, sm). This sclerite bears fewer setæ than the gula but they are much longer and project ventro-distad. The tough, membranous mentum is not visible on the ventral aspect. Firmly attached to the lateral and distal margins of the submentum, it is sharply retracted under that sclerite. On the dorsal aspect, it forms a tough, membranous rim (Fig. 10, m) which extends mesad from the free margins of the convex submentum. MacGillivray (1923) describes a membranous mentum which is more or less completely retracted under the submentum for *Calosoma calidum* F. and *Hydrous triangularis* Say. The inner margin of the mentum bears the fused stipulæ. The stipulæ are of delicate membranous structure easily pulled away from the tougher mentum which is stretched over the dorsal surface of the submentum like a drumhead. The delicate stipulæ (Fig. 9, 11, sp) are very irregular in form. They are flexible and may be extended and contracted by muscles attached to the ental surface. This interesting detail of their structure is indicated by the fact that two or three folds appear on their cephalic surface when they are contracted (Fig. 11). From the inner margin of the mentum the stipulæ extend dorsad bearing the palpigers, alaglossa, and paraglossæ. Caudo-dorsad they are attached to the skeletal structure of the parapharynx (Fig. 9). Two peculiar lobes project laterad from the stipulæ. These lobes (Fig. 9, 11, lb) are covered with tiny, sharp, disto-dorsad projecting spines. The palpigers (pp) are conspicuous structures borne on the latero-ventral portions of the stipulæ. Cephalad the palpigers are sub-cylindrical in form, but they taper caudad to rather delicate cord-like structures which are attached to the skeletal portion of the parapharynx (Fig. 11). The palpigers are largely membranous but they have a prominent heavily sclerotized spiral band which extends along the

lateral surfaces from the dorso-cephalic region ventro-caudad with a stem-like part passing far into the elongate caudal portion. A few large spiny setæ are borne on the latero-cephalic surfaces of the palpigers. Three segmental labial palpi (lp) are borne by the palpigers. The basal segment of the palpus is shorter than the others and has a smaller sclerotic band proximad. All of the segments have membranous regions distad to proximad sclerotic bands which bear a few setæ on the ventral aspects. The third segment bears numerous conical setæ (cs) on its distal end. The membranous paraglossæ are conspicuous structures arising from the stipulæ dorsad and mesad to the palpigers (Fig. 11, pgo). They are distinctly separated on the ventral aspect (Fig. 11) but they extend onto both surfaces of the labium and are completely fused on the dorsal aspect. As mentioned above, they extend on the dorsal aspect caudad to fuse with the subgusta, surrounding and fusing with the hypopharynx laterad and distad. (Fig. 7, pgo, hx). The paraglossæ bear a fringe of long hairs along their distal margins and minute spines project cephalad along their lateral margins. On the ventral aspect in the mesal region they bear a few spiny setæ projecting distad, while in the lateral regions of this and the dorsal aspect they bear many small hairs arranged in sub-semi-circular lines parallel to their distal margins. The strongly sclerotized alaglossa (Fig. 11, ago) lies in the mesal region between the ventral and dorsal surfaces of the paraglossæ. The mesarima is obsolete. The alaglossa is composed of two heavily-sclerotized, convex, sub-triangular structures of unequal length fused at their apices (Fig. 9, ago). The shorter part lies on the ventral aspect, the longer on the dorsal. The latter, dorsal part is fused with the stipulae along the dorsal surface of its caudal margin (Fig. 11, ago). The vestigial salivary duct, which in the adult has lost its taenidia, is fused with the ventral surface near the caudal margin of this same dorsal part of the alaglossa. There is no salivos or orifice of the salivary duct present.

SUMMARY.

The larval labrum bears numerous two-jointed hair-like processes near its distal margin which are found in few Coleopterous larvæ. These processes are articulated with conical bases which are integral parts of the labrum.

The larval mandibles are very similar to those of other mandibulate insects, but they bear an unusual membranous finger-like structure, the "Weichhäutiger Zapfen."

The larval maxillæ have a few characteristic points of structure. The cardo is divided into the subcardo and the alacardo. The galea is attached to the palpifer. The lacinia consists of two parts, a bidentate sclerotic structure and a membranous lobe, bearing the lacinarastra.

The larval epipharynx bears two prominent tooth-like processes which are attached to sclerotized areas in the labrum.

The sclerotic portions of the larval parapharynx are fused into the pharyngea-lingula and the salivias. The hypopharynx is completely fused with the paraglossæ except at the salivos.

In the larval labium the gula and submentum are fused. The mentum is separated from the stipulæ only by a delicate suture. The paraglossæ fuse with the dorsal arms of the stipulæ.

The imaginal mandibles bear both a suprabrustia and a prostheca.

The imaginal maxillæ have undivided cardos. The palpifer bears the galea, which is divided into the proxagalea and the distagalea. The subgalea bears the lacinia.

The imaginal epipharynx, extending beyond the margin of the labrum to which it is attached, forms a membranous rim there.

In the parapharynx of the adult the supporting sclerotic structures lie ventrad to the subgusta and the hypopharynx. These structures are fused into a horse-shoe shaped arch.

The imaginal labium has a membranous mentum which is retracted under the submentum. The flexible stipulæ, fused along the inner margin of the mentum, are attached caudo-dorsad to the skeletal structure of the parapharynx. They bear the palpigers, the alaglossa and the paraglossæ cephalad, and two peculiar, spiny lobes disto-ventrad. The palpigers are unusual in form as they are cylindrical distad but taper to a mere cord where they are attached to the skeletal portion of the parapharynx. The paraglossæ are fused with the hypopharynx and subgusta. The alaglossa lies in the mesal region between the ventral and dorsal surfaces of the paraglossa. The vestigal salivary duct is fused with the caudal margin of the dorsal surface of the alaglossa.

ACKNOWLEDGMENT.

The writer wishes to thank Dr. Clarence E. Mickel, Assistant Professor of Entomology, University of Minnesota, for aid and helpful suggestions given in the writing of this paper. Acknowledgment is made to Miss Ethel M. Slider, Technician of the Department of Zoology, for aid and advice in the preparation of the materials used. Thanks are due to Dr. A. G. Böving and Dr. R. E. Snodgrass for examining this paper and offering helpful suggestions.

BIBLIOGRAPHY.

Boving, A. G. 1921. The Larva of *Popillia japonica* Newman and a closely related undetermined Ruteline Larva. Proc. Ent. Soc. Wash. 23 (3): 51–62. 2 pl.

Bowerbank, J. S. 1837. Exhibitions, Memoirs, etc. . . . . Trans. Ent. Soc. London, Ser. I, Vol. II, Jr. of Proc., p. LX.

Buxton, P. A. 1921. The External Anatomy of the Sarcoptes of the Horse. Parasitology 13: 144.

Comstock, J. H. 1920. An Introduction to Entomology. pp. 29–165. Comstock Pub. Co., Ithaca, New York.

Crampton, G. C. 1921a. The Origin and Homologies of the So-called "Superlinguæ" or "Paraglossæ" (Paragnaths) of Insects and Related Arthropods. Psyche 28 (3): 84–92. 10 fig.

Crampton, G. C. 1921b. The Sclerites of the Head, and the Mouth Parts of Certain Immature and Adult Insects. Ann. Ent. Soc. Am. 14 (2): 65–110. 86 fig.

Crampton, G. C. 1922. A Comparison of the First Maxillæ of Apterygotan Insects and Crustacea from the Standpoint of Phylogeny. Proc. Ent. Soc. Wash. 24 (3): 65–82. 31 fig.

Crampton, G. C. 1923. A Phylogenetic Comparison of the Maxilla throughout the Orders of Insects. Jr. N. Y. Ent. Soc. 31 (2): 77–107. 6 pl.

Crampton, G. C. 1928. The Eulabium, Mentum, Submentum and Gular Region of Insects. Jr. Ent. and Zoo. 20 (1): 1–18. 38 fig.

Carpenter, G. H. and MacDowell, Mabel C. 1912. The Mouth Parts of Some Beetle Larvæ (*Dascillidæ* and *Scarabaeidæ*) with Especial Reference to the Maxillulæ and Hypopharynx. Quart. Jr. Micros. Sci. N. S. 57 (228) Pt. 4: 373–396. 2 pl., 5 fig.

Distant, W. L. 1877. Exhibitions, Memoirs, etc. . . . . Trans. Ent. Soc. London, Ser. III, Vol. XV, Jr. of Proc., p. XXII.

Handlirsch, A. 1928. Der Bau des Insektenkörpers und seiner Anhänge. Handbuch der Entomologie (C. Schröder) 1 (Leif. 36–37): 1186–1312. 190 taf. Gustav Fischer, Pub.; Jena.

Hansen, H. J. 1893. Zur Morphologie der Gliedmassen und Mundteil bei Crustacean und Insekten. Zool. Anz. 16 (420–421): 193–198, 201–212. 1873. Translated in Ann. & Mag. Nat. Hist. Ser. 6, 12 (72): 417–432.

Holland, W. J. 1896. Ravages of *Dermestes vulpinus* in Cork. Ent. News, 7 (3): 68.

Hollis, W. A. 1872. The Homologue of a Mandibular Palp in Certain Insects. Jr. Anat. Phys. Pt. 6, 2: 395–397. 1 pl.

Illingworth, J. F. 1918. The Leather Beetle (*Dermestes vulpinus* Fab.), a Troublesome Pest of Dried Fish in Hawaii. Proc. Hawaii Ent. Soc. 3: 375–378.

Imms, A. D. 1925. A General Textbook of Entomology. pp. 13–156; 456–472. Methuen & Co., Ltd., London.

Jones, F. M. 1889. *Dermestes vulpinus* in Goat Skins. Insect Life, 2 (3): 63–64.

Kadic, O. 1901. Studien über das Labium der Coleopteren. Jena Zeitschr. fur Naturwiss. 36 Bd. 1–2 Heft: 207–228. 1 taf.

Kimura, K., and Takakura, Y. 1919. Hidara Chugai Yobo ni Kwansuru Kenkyu. (Researches on Controlling Insects Injurious to Dried Cod Fish.) Exp. Rept. of the Fishery Institute. Tokyo, 15 (1): 1–32. 3 pl. Abst.; Rev. App. Ent. Ser. A, 8: 225–256. 1920.

Kraatz, G. 1859. Zur Terminologie der Paraglossen. Berl. Ent. Zeitschr. 1 Jahr: 54–59; 3 Jahr: 343–345.

Kreyenberg, J. 1928. Experimentell-biologische Untersuchungen über *Dermestes lardarius* L. und *Dermestes vulpinus* F. Zs. fur angewandte Ent. 14 (1): 140–188. 22 abb.

Lintner, J. A. 1884. The Bacon Beetle. Country Gentleman, 49: 537.

Lintner, J. A. 1887. The Leather Beetle. Boots and Shoes Weekly, 11: 473. May 25: 11: 608.

MacGillivray, A. D. 1923. External Insect-Anatomy. p. 6–143. Scarab Pub. Co.; Urbana, Ill.

MacGillivray, A. D. 1924. Crampton on the Labium of Certain Holometabola. Proc. Ent. Soc. Wash. 26 (5): 133–141. 1 pl.
Packard, A. 1889. Notes on the Epipharynx and the Epipharyngeal Organs of Taste in Mandibulate Insects. Psyche 5 (156–157): 193–199; 222–228.
Riley, C. V. 1886. The Leather Beetle or Toothed *Dermestes*. Report of Ent't. U. S. A. Dept. of Agr., 1885. pp. 258–264. 1 pl.
Roberts, A. W. R. 1926. On the early Stages of Some Weevils. (*Curculionibæ*). Ann. App. Biol. 13 (2): 197–218. 24 fig.
Schaum, H. 1861. Die Bedeutung der Paraglossen. Berl. Ent. Zeitschr. 5 Jahrg: 81–91.
Snodgrass, R. E. 1928. Morphology and Evolution of the Insect Head and its Appendages. Smithsonian Miscellaneous Collections, 81 (3): 2-158. Pub. No. 2971.
Snyder, T. E. 1920. The Lead Cable Borer. Wash. Acad. Sci. Jr. 10: 580.
Stickney, F. S. 1923. The Head-Capsule of Coleoptera. Ill. Biol. Monog. 8 (1): 1–105. 26 pl. Univ. Ill. Press. Urbana, Ill.
Van Zwaluwenburg, R. H. 1922. External Anatomy of the Elaterid Genus *Melanotus* (Coleop.) with Remarks on the Taxonomic Value of Certain Characters. Proc. Ent. Soc. Wash. 24 (1): 12–29. 2 pl.
Verhoeff, K. W. 1922. Über vergleichende Morphologie der Mundwerkzeuge der Coleopteren-Larven und Imagens, zugleich ein Beitrage zur Entwicklung, Biologie und Systematik der *Carabus-Larven*. Zool. Jahrb. Jena Abt. Syst. 44: 69–104. 4 taf.
Walker, J. J. 1884. Notes on *Dermestes vulpinus* and Other Beetles in Sheppey. Ent. Mo. Mag. London, 21: 161.

EXPLANATION OF PLATES.

The Mouth Parts.

If the figures No. 9, Plate I and No. 12, Plate II, are taken as a standard of 1, then figures No. 3, Plate I, and Nos. 2, 4, 5, 11, Plate II, are drawn to the scale of ×4 and the remaining figures are all drawn to the scale of ×2.

Plate I.

Larval Mouth Parts. Scale, ×59.

Fig. 1. Left Mandible, ventral view.
Fig. 2. Left Mandible, dorsal view.
Fig. 3. Labrum, dorsal view.
Fig. 4. Jointed-hairs enlarged.
Fig. 5. Left Maxilla, ventral view.
Fig. 6. Prepharynx, internal view.
Fig. 7. Labium, ventral view.
Fig. 8. Labium, lateral view.
Fig. 9. Larval head, ventral view.

Plate II.

Adult Mouth Parts. Scale, ×59.

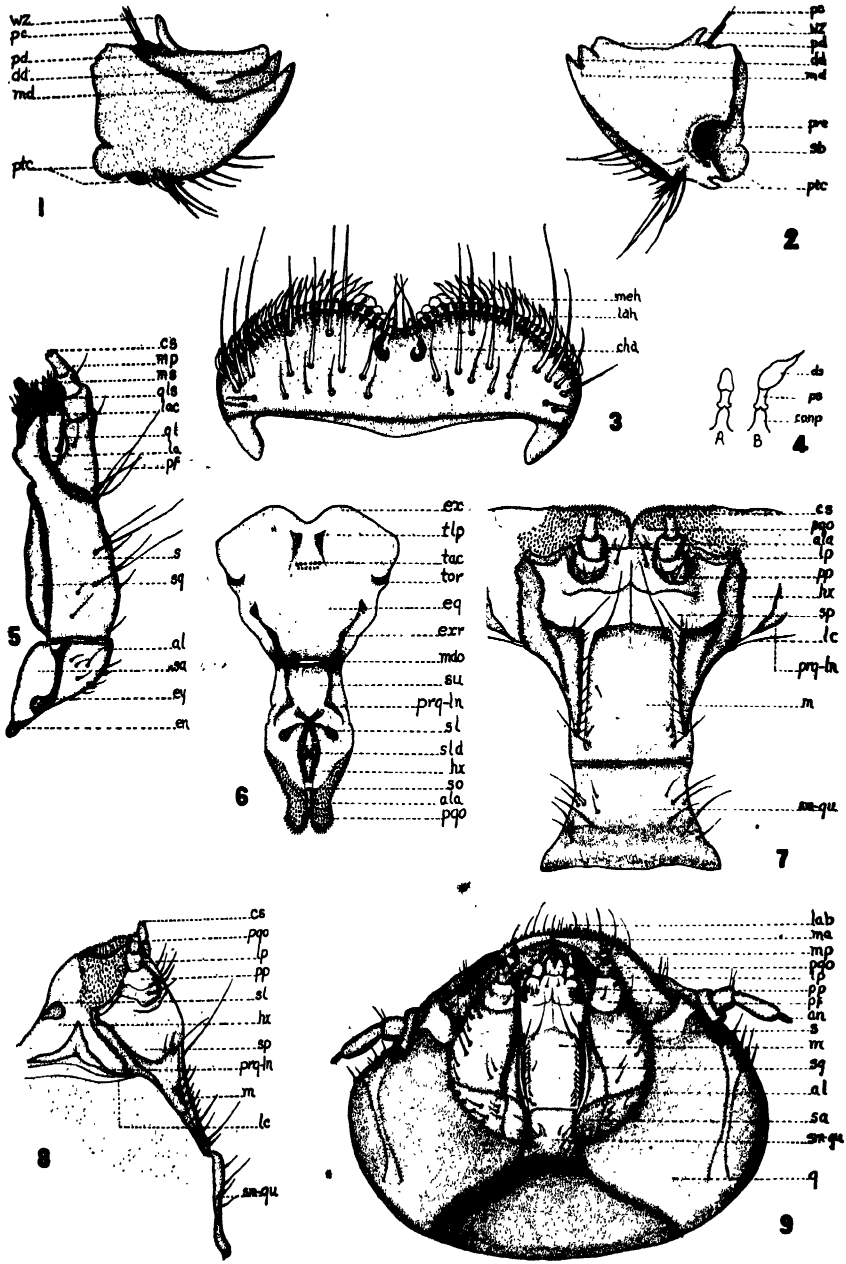
Fig. 1. Left Mandible, ventral view.
Fig. 2. Labrum, dorsal view.
Fig. 3. Left Mandible, dorsal view.
Fig. 4. Epipharynx, dorsal view.
Fig. 5. Labrum and Epipharynx, longitudinal section.
Fig. 6. Right Maxilla, ventral view.
Fig. 7. Prepharynx, internal view.
Fig. 8. Right Maxilla, dorsal view.
Fig. 9. Labium, lateral view.
Fig. 10. Gula, Submentum, and Mentum, dorsal view.
Fig. 11. Labium with Submentum and Mentum removed, ventral view.
Fig. 12. Adult Head, ventral view.

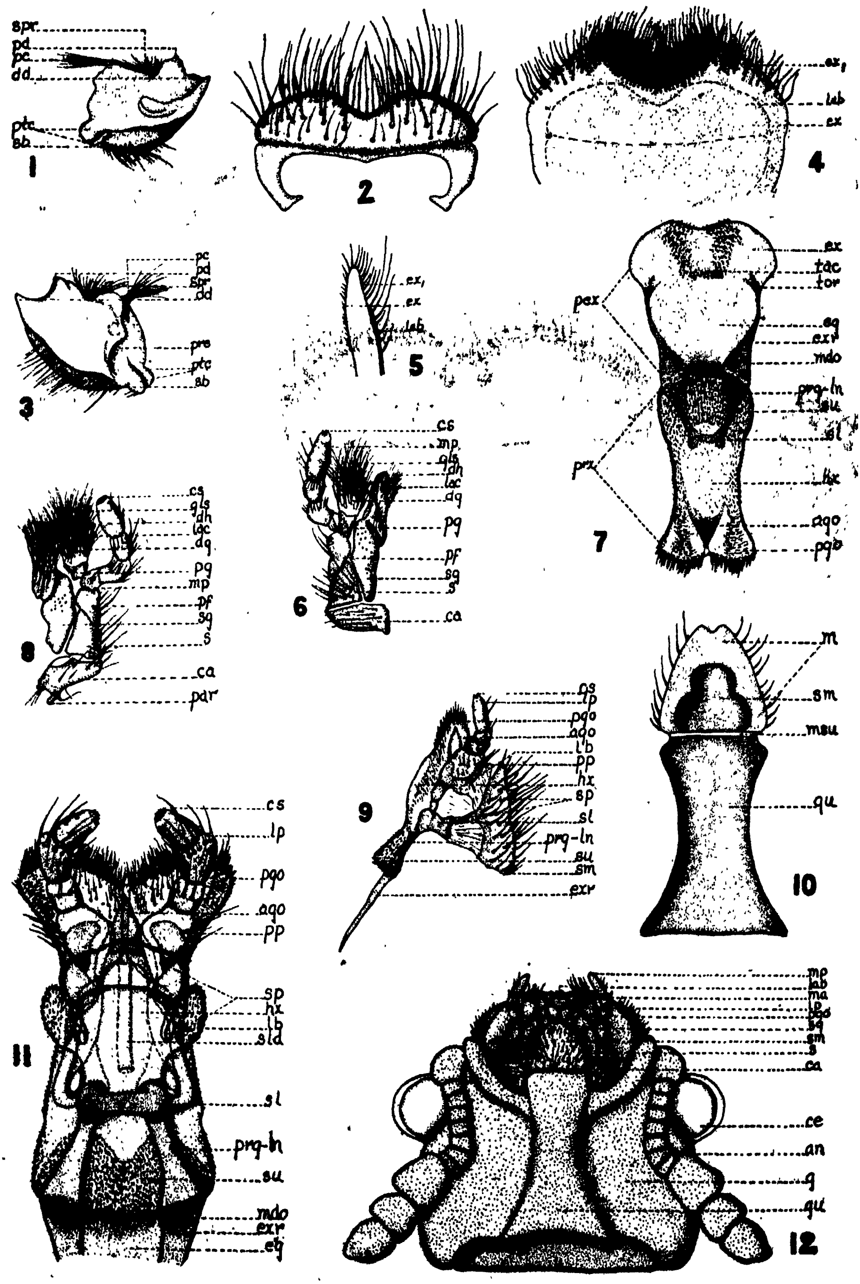
ABBREVIATIONS.

A—mesal jointed-hair.
ago—aloglossa.
al—alacardo.
ala—alarima.
an—antenna.
B—lateral jointed-hair.
bs—basal segment.
ca—cardo.
ce—compound eye.
cha—chitinous area.
conp—conical projection.
cs—conical setæ.
dd—distadentis.
dg—distagalea.
dh—distal hook.
ds—distal segment.
eg—epigusta.
en—entoparartis.
ex—epipharynx.
exr—epipharyngeal rod.
ey—exparartis.
g—gena.
gl—galea.
gls—galarastra.
gu—gula.
hx—hypopharynx.
la—lacinia.
lab—labrum.
lac—lacinarastra.
lah—lateral jointed-hair.
lb—lobe of the stipulæ.
lc—labacoria.
lp—labial palpus.
m—mentum.
ma—mandible.
m-sm—mentum-submentum.
md—middentis.
mdo—mandoris.
meh—mesal jointed-hair.
mp—maxillary palpus.
mr—mesarima.
ms—maxadentis.
par—parartis.
pc—prostheca.
pd—proxadentis.
pex—propharynx.
pf—palpifer.
pg—proxagalea.
pgo—paraglossa.
pp—palpiger.
prg-ln—pharyngea-lingula.
prx—parapharynx.
ptc—postartis.
s—stipes.
sa—subcardo.
sb—scrobe.
sg—subgalea.
sl—salivia.
sld—salivary duct.
sm—submentum.
sm-gu—submentum-gula.
so—salivos.
sp—stipulæ.
spr—suprabrustia.
su—subgusta.
tac—taste organ.
tlp—tooth-like process.
tor—torma.
WZ—Weichhautiger Zapfen.

Mouth-parts of Dermestes
Verna E. Robinson

Plate I.




spr
pd
pc
dd
ptc
sb
1
2
ex,
lab
ex
4
pc
pd
spr
dd
pre
ptc
sb
3
ex,
ex
lab
5
ex
tac
tor
pex
eq
exr
mdo
prq-ln
su
sl
prx
hx
aqo
pqo
7
cs
mp
gls
dh
lac
dq
pq
pf
sq
s
ca
6
cs
gls
dh
lac
dq
pq
mp
pf
sq
s
ca
pdr
8
m
sm
msu
qu
10
cs
lp
pqo
aqo
lb
pp
hx
sp
sl
prq-ln
su
sm
exr
9
cs
lp
pqo
aqo
pp
sp
hx
lb
sld
sl
prq-ln
su
mdo
exr
eq
11
mp
lab
ma
lp
pqo
sq
sm
s
ca
ce
an
q
qu
12

SOME ERYTHRONEURA OF THE OBLIQUA GROUP (HOMOPTERA, CICADELLIDÆ).*

R. H. BEAMER,
University of Kansas.

The writer has been interested in this genus of insects since 1924 when Wm. Robinson worked out the classification with the male genitalia as a basis. Among the several hundred specimens in the Snow Entomological Collection called *Erythroneura obliqua* (Say) great variation was found. Not only was there considerable variation in dorsal color pattern but some had very dark abdomens, others very light, some were very small and still others were quite large. Could all this variation of external appearance be accounted for by variation within the species? The work of Robinson had given a good foundation upon which to work.

Dissection of supposedly *Erythroneura obliqua* males then began. The number of kinds of male genitalia found immediately was almost staggering. Males with black abdomens were always different from those with white. Black abdomened males with black mesosterni were different from those with light mesosterni. A difference in the inverted V mark of the vertex showed a difference in male genital structure. The same was true of pronotal markings and so on. Even differences of genital structure appeared where no apparent external difference was noticeable. It was even difficult to find more than one of a kind at first. It immediately became evident that the first thing to be settled was what variation, if any, could be expected in the male genital apparatus. Accordingly numerous specimens of a species, easily recognized externally, were selected and dissected.

The first species chosen was *E. crevecoeuri* (Gill.). Six males of this species were taken from localities as far apart as possible and dissected. A comparison of genital structure showed them to be as near alike as six peas in the same pod. Several hundred dissections have thus been made of quite a

*Contribution from the Department of Entomology, University of Kansas, Lawrence, Kansas.

number of species and with like results. It seems reasonable to suppose then, that there would be practically no variation found in the genital apparatus of the same species. However, only after more than one thousand dissections had been made and the discovery that certain specimens with the same genitalia came from certain definite hosts, was it decided that all these types of genital structure were indicative of good species. Where but one or two specimens have been found of a kind they have not been included although there is no question but that more dissections of specimens from these localities will yield more of the same type.

An effort has been made to study as many of the species previously named in this group as possible. Robinson's types were all at hand and W. L. McAtee very generously loaned the writer all of his type material for dissection so that by far the most of the species have been studied.

It has been found that only the posterior end of the styles and oedagus with its base and processes are of diagnostic value. The posterior portion of the style (Pl. I, Fig. 3) a, will be spoken of hereafter as the foot, b, the heel, c, base of foot, d, anterior point and e, posterior point.

Sixty-four species and varieties are represented; seven of these are raised from varietal to specific rank, 44 are new and the male genitalia of all of them have been studied.

KEY TO THE SPECIES.

1. Principal color markings on tegmina transverse nor covering most of surface.......... 2
   Principal color markings on tegmina not transverse or covering most of surface, usually light colored with yellow or orange oblique vittae......17
2. Markings transverse or covering basal half of tegmina, not back to cross-veins.......... 3
   Dark color covering tegmina at least back to cross-veins.......... 4
3. Narrow red band across middle; pronotum and scutellum red, **rubroscuta** (Gill.) (1)
   Red to dusky band (usually lighter in middle) across basal half of tegmina..........**crevecoeuri** (Gill.) (2)
4. One or two large heart-shaped white spots on median line; anterior point of style less than a right angle.......... 5
   No definite white spots.......... 7
5. One heart-shaped or diamond-shaped spot from tip of scutellum to tip of clavus.......... 6
   Two heart-shaped spots on tegmina; beyond cross-veins some cells hyaline..........**electa** McA. (3)
6. Base of oedagus with large lateral horns..........**bifurca** n. sp. (4)
   Base of oedagus without large lateral horns..........**pulchra** n. sp. (5)
7. Indefinite white spots on tegmina or sides of head white.......... 8
   Evenly colored to cross-veins.......... 9

8 Two indefinite white spots on tegmina **fumida** (Gill) (6)
Tegmina black, large species **atrimucronata** n sp (7)
9 Usually with more or less definite oblique stripes 10
Usually evenly colored species 13
10 Usually with definite oblique stripes 11
Oblique stripes absent 12
11 Western (Ill , Kans , etc), posterior point of style sickle-shaped, **kanza** Rob (8)
East coast species, style with short, sharp, posterior point **varia** McA (9)
12 Oedagus three-branched **brundusa** Rob (10)
Oedagus with a cross-bar just before tip **iconica** McA (11)
13 Tegmina colored to cross-veins 14
Tegmina colored throughout 15
14 Tegmina semihyaline with pinkish tinge **abolla** McA (12)
Tegmina reddish, white hickory as host var **accensa** McA (13)
15 Tegmina wine colored on costa at least **vinaria** n sp (14)
Tegmina uniform dusky or smoky 16
16 East coast species, oedagus with single shaft **iconica** McA (11)
Central states species, oedagus trident-like **brundusa** Rob. (10)
17 At least some dark color on abdomen 18
No dark on abdomen 47
18 Vittae of dorsum run together with either red or black 19
Vittae of dorsum not run together with red or black 23
19 Vittae on vertex usually solid red, oedagus with large processes, **lawsoniana** Bak (15)
Vittae on vertex yellow or dusky 20
20 Vittae on vertex broadly touching eye, shaft of oedagus with lateral blunt tooth one-third distance from tip 21
21 Tegmina with oblique vittae **penelutea** n sp (16)
Tegmina without oblique stripes **divisa** McA. (17)
22 Dorsum dark red **rufostigmosa** n sp. (18)
Dorsum with red stripes connected with black var **subnubila** n var. (19)
23 Vertex with two sooty black spots 24
Vertex without two sooty black spots 26
24 Face with two black spots **oculata** McA. (20)
Face without two black spots 25
25 Spots on vertex separated by diameter of one of them, pygofer with three processes and one spine **quadricornis** n sp (21)
Spots separated by diameter of two spots, two processes and one spine on pygofer **apacha** Bak. (22)
26 Styles with posterior point sickle-shaped 27
Styles with posterior point not sickle-shaped 28
27 Oedagus much widened laterally with slender projection near tip, **falcata** n sp (23)
Oedagus not widened, but with arcuate processes arising at base, **harpax** n sp (24)
28 Oedagus without processes arising at base 29
Oedagus with processes arising at base 37
29 Posterior point of style broad, almost parallel-sided 30
Posterior point shorter, sharp, not parallel-sided 31
30 Darkened on median line, two lateral projections near tip of oedagus, **cotidiana** n sp (25)
Not darkened on median line, no processes on oedagus **cuneata** n sp (26)
31 Posterior point of styles narrower than anterior point 32
Posterior point of styles of about same width or wider than anterior 35
32 Oedagus with distinct processes just before tip 33
Oedagus without distinct processes before tip 34
33 Processes close to tip of shaft where they turn abruptly out **diffisa** n sp (27)
Processes project out from shaft directly **torra** Rob. (28)
34 Oedagus with quadrate tip **quadrata** n sp (29)
Oedagus with tapered tip **parvispicata** n sp (30)

35. Outer margin of anterior and posterior points of styles almost forming a straight line .... **coarctata** n. sp. (31)
Outer margins of points distinctly angled 36
36. Oedagus divided at tip .... **aenea** n. sp. (32)
Oedagus not divided at tip .... **gleditsia** n. sp. (33)
37. Anterior point of style about a right angle 38
Anterior point of style not a right angle 41
38. Posterior point of style straight-sided 39
Posterior point of style curved 40
39. Processes short; close to shaft .... **fulvocephala** Rob. (34)
Processes long; arise below base of shaft .... **penenoeva** n. sp. (35)
40. Processes short, arising above base of shaft .... **noevus** (Gill.) (36)
Processes long, arising at base of shaft .... **obvia** n. sp. (37)
41. Anterior point of style as long as or longer than posterior 42
Anterior point of style shorter than posterior 43
42. Anterior point of style twice as long as posterior; processes half as long as oedagus .... **rubens** n. sp. (38)
Anterior point equal to posterior point; processes almost equal to length of oedagus .... **rubrataeniensis** n. sp. (39)
43. General ground color reddish brown except for a very large white spot occupying disc of tegmina 44
General ground color whitish 45
44. Base of oedagus with large lateral horns .... **bifurca** n. sp. (4)
Base of oedagus without large lateral horns .... **pulchra** n. sp. (5)
45. Shaft of oedagus shaped like an arrowhead .... **sagittata** n. sp. (40)
Shaft of oedagus almost straight 46
46. Shaft of oedagus smaller; processes with broad lanceolate tips **funesta** n. sp. (41)
Shaft of oedagus heavier; processes curving away from shaft, with teeth near their middle .... **plena** n. sp. (42)
47. Posterior point of style with sides almost parallel 48
Posterior point of style with sides converging sharply 58
48. Oedagus without processes arising at base of shaft 49
Oedagus with processes arising at base of shaft 55
49. Oedagus without lateral projections 50
Oedagus with lateral projections 51
50. With a black dorsal stripe, oedagus very long, curved .... **stolata** McA. (43)
Without a black dorsal stripe; oedagus short, posterior point very long and slender, **albescens** n. sp. (44)
51. Lateral processes sharp-pointed 52
Lateral processes blunt 54
52. Lateral processes at right angles to shaft, one-third distance from tip, **cruciformis** n. sp. (45)
Lateral processes not at right angles to shaft 53
53. Tip of oedagus dorso-ventrally spatulate .... **spatulata** n. sp. (46)
Tip of oedagus not dorso-ventrally spatulate .... **tenuispica** n. sp. (47)
54. Shaft of oedagus almost parallel-sided; lateral processes very short, **volucris** n. sp. (48)
Shaft of oedagus tapering; processes larger .... **eluta** McA. (49)
55. Processes diverging from base of shaft almost at right angles; posterior points sickle-shaped .... **hamata** n. sp. (50)
Processes not diverging from base of shaft 56
56. Processes parallel with shaft entire length .... **infinita** n. sp. (51)
Processes not parallel with shaft entire length 57
57. Processes bending at right angles to shaft near tips .... **angularis** n. sp. (52)
Processes evenly curved out; enlarged leaf-like at tip .... **latapex** n. sp. (53)
58. Shaft of oedagus without processes at base 59
Shaft of oedagus with processes at base 62
59. Shaft of oedagus with blunt lateral teeth just before tip 60
Shaft of oedagus without teeth 61
60. Base of foot of style arcuate posteriorly .... **modica** n. sp. (54)
Base of foot straight .... **scissa** n. sp. (55)

61. Tip of oedagus rounded and grooved like a hoof..........**cornipes** n. sp. (56)
Tip of oedagus flattened and extended laterally into a cross-bar half as long as shaft..............................**malleiformis** n. sp. (57)
62. Processes at sides of shaft..63
Processes ventrad to shaft..65
63. Processes very short, on lateral margins..................**modica** n. sp. (54)
Processes long; two-thirds length of shaft or longer.......................64
64. Processes as long as shaft..............................**tridens** n. sp. (58)
Processes two-thirds as long as shaft....................**bicornis** n. sp. (59)
65. Processes not over half length of shaft.......................................66
Processes over half length of shaft..67
66. Processes close to base of shaft; posterior point more than half as long as base ....**obliqua** (Say) (60)
Processes arising below base of oedagus; posterior point about one-third length base of foot; heel large......................**magnacalx** n. sp. (61)
67. Long anterior point...............................**furcilliata** n. sp. (62)
Almost no anterior point..68
68. Oedagus with broad tip in side view.................**unicuspidis** n. sp. (63)
Oedagus with very narrow tip in side view...........**penobliqua** n. sp. (64)

1. **Erythroneura rubroscuta** (Gill.)

Typhlocyba rubroscuta Gillette. Proc. U. S. Nat. Mus., vol. XX, p. 755; 1898.

This species has been correctly identified by Robinson and others. It is very common in Kansas and may be taken in numbers on buckeye in the early spring when this tree leafs out. At this time the specimens are often pure white instead of having the two red cross bars.

A male of the Cotype Series has been dissected and designated as the allotype.

Genitalia. (Pl. I, Fig. 1.)
Style with foot rather long and narrow; heel large; base almost straight; anterior point sharp, directed laterally; posterior point much shorter than anterior, its outer margin in a direct line with outer margin of anterior point, inner margin forming less than a right angle with base of foot. These points resemble a crochet hook. Oedagus curved in lateral view with a pair of processes arising near base of shaft and extending out for about half the length of shaft.

Allotype deposited in the U. S. Nat. Mus.

2. **Erythroneura crevecoeuri** (Gill.)

Typhlocyba crevecoeuri Gillette, C. P. Proc. U. S. Nat. Mus., vol. XX, p. 767; 1898.

Genitalia. (Pl. I, Fig. 2.)
Style with medium foot; heel large; anterior point short and sharp; posterior point broad, about half as long as base of foot, almost parallel-sided, converging abruptly. Oedagus long, curved in lateral view, ending in a widened bifid tip.

Common on buckeye in Kansas in early spring.

3. **Erythroneura bifurca** n. sp.

General ground color brown. Vertex tinged with orange; two small white spots near margin. Pronotum with a semblance of two orange to brown vittæ. Scutellum brown or orange. Tegmina with usual oblique orange vittæ. A light cross-band from tip of scutellum to tip of clavus. Venter dark. Femora dusky.

Genitalia. (Pl. I, Fig. 3.)

Styles with moderate foot; heavy heel; base sinuate; anterior point very short and narrow, projecting out; posterior point about half length of base of foot, almost as wide as toe. Oedagus with bifurcate base, shaft straight with a flattened tip; two processes arise at base of shaft, diverge rapidly to sides of shaft and run parallel with it for almost its entire length.

Holotype, male, Cherokee Co., Kans., 1928, R. H. Beamer.

Allotype, female, Johnson Co., Ill., March 30, 1929, R. H. Beamer.

Paratypes, three males, Cherokee Co., Kans.; 2 males and 1 female, Johnson Co., Ill.; 2 males Gallatin Co., Ill.; 1 male, White Co.; Ill., 4 males and 2 females, Lawrence Co., Ill., R. H. Beamer and P. W. Oman.

A beautiful, distinct species of much the same appearance as *E. pulchra* n. sp. from Tenn.

4. **Erythroneura pulchra** n. sp.

General ground color reddish brown; a lighter circular cross-band extends from tip of scutellum to tip of clavus. Vertex with a white circular spot on margin either side middle, a semblance of a lighter median line. Pronotum with two longitudinal, oval, darker spots. Scutellum with tip brighter red and a median longitudinal whitish stripe extending from anterior margin toward tip. Clavi and coria with ordinary broad oblique stripes through white cross-band. Extreme tip of tegmina darker. Anterior half of face dark orange, remainder shading into black. Mesosternum black. Abdomen dark.

Genitalia. (Pl. I, Fig. 4.)

Style with medium foot; curved base; prominent heel; smaller toe; anterior point narrow and short, about one-third size of posterior; the latter heavy, turning out and caudad, both sides curved. Oedagus of medium length, almost straight; ventral side hollowed out at tip; some close ventral processes at base. Ventrad of base of shaft a well developed swelling.

Holotype, male, Nashville, Tenn., Dec., 1927; R. H. Beamer.

Allotype, female and one paratype, same data.

5. **Erythroneura electa** McA.

Erythroneura obliqua var. *electa* McAtee. Trans. Am. Ent. Soc., XLVI, p. 282; 1920.

General ground color milky white. Vertex with inverted orange V whose outer margin follows edge of eyes; continued across pronotum as a pair of diverging or widening vittæ. Scutellum mostly reddish; white vittæ may be present. Tegmina dusky with customary oblique orange vittæ on clavi and coria; two contiguous, heart-shaped white spots on median line between tip of scutellum and tip of clavus, the posterior one with orange dash usually formed by continuance of claval vittæ. Third and fourth apical cells hyaline, venter dark, face dusky, suffused with orange.

Genitalia. (Pl. I, Fig. 5.)

Style with foot small; base almost straight; heel prominent; anterior point third width and length of posterior, quite sharp; posterior point almost parallel sided, blunt pointed, about third length of foot. Oedagus straight, of medium length, tip flattened and widened with two parallel processes almost as long as shaft, with flat sword-shaped ends.

This species is well marked by the two sharply outlined heart-shaped white spots on dorsum and the clear third and fourth apical cells. Most specimens have definite orange vittæ on vertex and pronotum, differing in this particular from the original description.

6. **Erythroneura fumida** (Gill.)

Typhlocyba obliqua var. *fumida* Gillette. Proc. U. S. Nat. Mus., vol. XX, p. 758; 1898.

Dark colored species. Vertex yellowish white with an orange inverted V; basal part of V narrow, upper arms much enlarged. Pronotum with two small, oval, diverging, orange marks not touching either margin. Anterior border yellowish white, remainder dusky. Scutellum dark, suffused with red. Tegmina dusky with three oblique red vittæ and the following heart-shaped white spots: one at base of scutellum and one at tip of clavus. Face orange. Mesosternum shining black. Abdomen dark.

Genitalia. (Pl. I, Fig. 6.)

Style with foot large; base slightly sinuate; heel heavy; anterior point about a right angle; posterior point about as long as width of toe, sides converging. Oedagus, in lateral view, curved, of medium length, with a pair of processes arising at base of shaft, diverging astride shaft one-third distance before tip.

Type, female, No. 3445 U. S. N. M. from Onaga, Kansas.

Allotype, male, Anderson Co., Kans., Nov. 26, 1927, R. H. Beamer.

7. **Erythroneura atrimucronata** n. sp.

General ground color black with a purplish tinge on tegmina. Margins of vertex and pronotum yellowish white. The black color starts in a point on the vertex and becomes wider until it occupies the entire dorsum near anterior end of costal plaque. Face and sternum pinkish. Abdomen dark.

Genitalia. (Pl. I, Fig. 7.)

Style with foot of medium size; heel short; anterior point about a right angle; posterior point short, sharp, slightly bent in. Oedagus long, in lateral view, curved, thick, with an enlargement on ventral side near the middle. In ventral view there is a widening with rough edges near middle and tip is split into two outward projecting processes.

Holotype, male, Johnson Co., Ill., March 30, 1929; R. H. Beamer.

Allotype, female, same data.

Paratypes, 3 males and 4 females, Johnson Co., Ill., R. H. Beamer and P. W. Oman.

This is one of the largest species of *Erythroneura*. It resembles in general appearance both *E. stolata* McA. and *E. aclys* but is larger than either one of them.

8. **Erythroneura kanza** Rob.

Erythroneura kanza Robinson Can. Ent., Vol. LVI, No. 3, p. 58; 1924.

Genitalia (Pl. Fig. 8.)

Styles with large foot; base sinuate; heel large; anterior point about a right angle; posterior point longer than foot, sickle-shaped, forming an even curve with base of foot. Oedagus long, slightly curved in lateral view, with heavy lateral processes arising just before tip, turning out at right angles to it

9. **Erythroneura varia** McA.

Erythroneura abolla var. *varia* McA. Trans. Am. Ent. Soc., XLVI, p. 287; 1920.

General ground color semi-hyaline to whitish becoming opaque on vertex and anterior margin of pronotum. Vertex dull rose colored with irregular shaped yellowish white spot at base and two spots on margin. Pronotum with lateral and anterior margins yellowish white, disc dusky bordered by posteriorly diverging rose-vittæ. Scutellum dusky suffused with red. Tegmina with three longitudinal rose colored vittæ, inner one occupying outer two-thirds of clavus, second beginning opposite anterior end of costal plaque on Cu and ending at cross-veins and third on costal margin to cross-veins, except costal plaque. Abdomen and mesosternum dark. Apical half of tibiæ dark. Face reddish with median light vitta.

Genitalia. (Pl. I, Fig. 9.)

Style with medium foot; base almost straight; heel small, projecting; anterior point about a right angle; posterior point one-third length of base of foot, narrow. Oedagus with heavy base, curved dorsally; a pair of processes arising at base of shaft, reaching three-fourths its length where they separate appearing to straddle it. Resembles genitalia of *abolla* McA. but differs from that species in shape of styles, etc.

Externally this species resembles *kansa* Robinson but the genitalia are entirely different.

Dissection made from Holotype, male, Mt. Vernon, Va., Feb. 28, 1915, W. L. McAtee. Deposited in his collection.

10. **Erythroneura brundusa** Rob.

Erythroneura brundusa Robinson. Can. Ent., Vol. LVI, No. 7, p. 155; 1924.

Genitalia. (Pl. I, Fig. 10.)
Style with medium foot; base straight; heel small; anterior point about half length of posterior, sharp; posterior point slightly narrower at base than anterior, about one-fourth length of foot. Oedagus straight with lateral processes arising before base of shaft, diverging from it and ending slightly beyond tip. The oedagus with its processes looks like a three-pronged fork or trident.

This species is commonly taken on *Gleditsia.*

11. **Erythroneura iconica** McA.

Erythroneura abolla var. *iconica* McA. Trans. Am. Ent. Soc., XLVI, p. 287; 1920.

General color fumose often tinged with red. Vertex yellowish white with a darker spot near eye at each basal angle, roughly rectangular and extending toward apex. Pronotum with light color of lateral and anterior margins in shape of a semicircle; disc dark. Scutellum darker than rest of dorsum. Tegmina evenly dusky throughout except costal plaque which is whitish. Venter of abdomen and mesosternum dark. Face reddish with light median spot and two larger apical light circles touching eyes and almost one another, with a darkened dash or spot in their centers.
Genitalia. (Pl. I, Fig. 11.)
Styles with medium foot; base almost straight; heel moderate; anterior point about a right angle; posterior point heavy, almost as long as base of foot; almost parallel for a portion of their length. Oedeagus of medium length, slightly bent dorsally, right angled projection with rather broad base, either side three-fourths distance to tip. Ends in flattened arrow head slightly wider than shaft.

This species will be confused externally with *E. brundusa* Rob. which is a Mississippi Valley species, is larger and is totally unlike it in male genitalia. The internal male genitalia resemble those of *E. divisa* McA. but the oedagus is shorter.

base of processes on shaft are broader and the styles differ in shape and the pygofer hook of *divisa* is flat on outer curve. Externally *divisa* has a median dorsal dark stripe.

Dissection made of a Paratype, male, Mt. Vernon, Va., Feb. 28, 1915. W. L. McAtee. Deposited in his collection.

12. **Erythroneura abolla** McA.

Erythroneura abolla McAtee. Trans. Am. Ent. Soc., XLVI, p. 285; 1920.

I have seen this species only from East coast states. Specimens from Kansas, Illinois, etc., resembling it in external appearance, show genitalia closer to *iconica* McA.

Genitalia. (Pl. I, Fig. 12.)

Style with medium foot; base almost straight; heel medium; anterior point short, about a right angle; posterior point broad, almost as long as base of foot. Oedagus almost straight to tip where it curves sharply dorsad; with a pair of processes arising below base of shaft, extending two-thirds its length, enlarged on outer half.

Dissection made of a Paratype, male, Mt. Vernon, Va.

13. **Erythroneura abolla** var. *accensa* McA.

Erythroneura abolla var. *accensa* McAtee. Trans. Am. Ent. Soc., XLVI, p. 288; 1920.

A dissection of the Allotype of *accensa* exhibited genitalia identical with those of a paratype of *E. abolla* McA. It is, therefore, correctly placed as a variety of that species.

Six females and 2 males of this variety were taken from white hickory in Arkansas by the writer in August, 1928.

14. **Erythroneura vinaria** n. sp.

General ground color dusky throughout with the following wine colored or dusky markings: a pair of rectangular-shaped spots at base of vertex; some with a pair of parallel vittæ on disc of pronotum not reaching either margin; a V-shaped mark on scuttellum; a semblance of a vitæ near middle of clavi; a vitta following Cu from about opposite middle of clavus to cross-veins; and a broader stripe from humeral angle to cross-veins excepting costal plaque. Dorsum of abdomen fuscous. Mesosternum shining black. Face reddish brown. Beneath and about the eyes wine-red. Apex of vertex with three whitish spots. Some specimens are wine-red throughout. Beyond cross-veins darker. Some specimens have a more or less hyaline area on inner margin of clavi and just in front of cross-veins giving somewhat a banded appearance. The wine color is especially evident anterior to costal plaque.

Genitalia. (Pl. I, Fig. 13.)

Styles with medium foot; prominent heel; base sinuate; anterior point about a right angle; posterior point short with sides converging. Oedagus of medium length, curved dorsally, quite thick from lateral view, has a flattened process arising at base of shaft ending in a heart-shaped lobe three-fourths distance to tip. Tip flattened dorso-ventrally and ending in a laterally widened tip.

Holotype, male, Anderson Co., Kansas, Nov. 26, 1927; R. H. Beamer.

Allotype, female, same data.

Paratypes, males 23, females 24, same data.

This species may be picked out by its general dusky color with the wine colored costal stripe.

15. **Erythroneura lawsoniana** Bak.

Typhlocyba obliqua var. *dorsalis* Gillette. Proc. U. S. Nat. Mus., Vol. XX, p. 757; 1898.
Erythroneura lawsoni Baker. Phil. J. Sci., Vol. 27, p. 537; 1925.
Erythroneura lawsoniana Baker. Phil. J. Sci., vol., 28, p. 347; 1926.

General ground color pearly white. Vertex with inverted, triangular, reddish-orange colored spot, not quite touching eye at base; continued across pronotum as a posteriorly widening band occupying most of disc, in some specimens this may be fumose near the middle; also all of scutellum, all of clavi except small portion at base, and on coria as a broad stripe beginning at middle of costal plaque and extending to cross-veins. Cell M_4 fuscous. Often the inner margin of clavi may be fumose. Immature specimens may be almost entirely fumose. Face orange to yellow, mesosternum and abdomen more or less dark. Hind tibial spines either dark or light.

Genitalia. (Pl. I, Fig. 14.)

Styles with medium foot; heel large; anterior point half as long as posterior, one-third as wide at base; posterior point more than half as long as foot. Oedagus with heavy base, with large lateral processes as well as a pair of slender ones extending almost parallel with shaft, ending in ventrally recurved hooks; shaft long and slender, almost straight; ending in a bifid tip.

This is one of the *Erythroneura* which is to be found on apple and in some cases does considerable damage.

16. **Erythroneura penelutea** n. sp.

General ground color opaque white. Vertex with yellow inverted V whose outer edges touch eyes. This inverted V continued almost across pronotum in form of widening red vittæ. Remainder of disc dusky. Lateral margins and spot on anterior margin light. Scutellum dusky with red near tip. Tegmina with two red oblique vittæ, first occupying outer half of clavus and other Cu from about even with middle of clavus to cross-veins. An orange stripe arises at base of eye and

extends on costal margin almost to costal plaque. Cross-veins light. Spots before cross-veins and apical cells dusky. Venter stramineous with some darker spots.

Genitalia. (Pl. I, Fig. 15.)

Styles with average foot; sinuate base; prominent heel; anterior point about a right angle; posterior point almost as long as base of foot, sides almost parallel, inner margin forming smooth curve with base of foot, pygofer hook of common *obliqua* type. Oedagus of medium length, curved dorsally with a diamond-shaped process on ventral side about three-fourths distance to tip. Ends in a flattened and widened tip bent at right angles to shaft.

Holotype, male, Douglas Co., Kans., May 1, 1926.

Allotype, female, same data.

Paratypes from the following localities: Douglas Co., Kans., May 1, 1926; 54 males and 20 females. Leavenworth Co., Kans., April 8, 1928; 16 males and 2 females.

The dark coloring between vittæ of pronotum and clavi and on scutellum give this species the appearance of a light colored *E. rufostigmosa* var. *subnubilis* Beamer from which it may be separated by the inverted V usually broadly touching the eye.

17. **Erythroneura divisa** McA.

Erythroneura abolla var. *divisa* McAtee. Florida Ent., p. 37, Vol. VIII, Nos. 3 and 4, December, 1924.

General ground color sulfur yellow. Vertex with a narrow median line reaching two-thirds distance to apex. A very light comma-shaped dark line either side of end of mesal line. Pronotum with lateral and anterior margins sulfur yellow, disc darkened by the beginning of the dark dorsal stripe which covers scutellum, except extreme basal angles, and inner half of clavi, ending at apex of tegmina. Venter mostly stramineous, some indication of darker spots on abdomen. Dorsum of abdomen much darker.

Genitalia. (Pl. I, Fig. 16.)

Style with medium foot; base slightly curved; heel moderate; anterior point about a right angle; posterior point about as long as base of foot, almost parallel-sided, slightly arcuate. Pygofer hook tends to be flattened on the outer curve. Oedagus with shaft long, somewhat curved in lateral view, a pair of slim processes project at right angles from its shaft about three-fourths distance from the tip. Ends in a flattened arrow-shaped process about as wide as shaft itself.

This species was named as a variety of *E. abolla* McA. but according to the male genitalia it should be raised to specific rank. It is close to *iconica* McA. from which it may be distinguished by having the dorsal stripe limited to the median line.

18. **Erythroneura rufostigmosa** n. sp.

General ground color semihyaline on tegmina to opaque white on pronotum and vertex. Dorsally marked with a red stripe arising on apex and growing wider to tips of tegmina. Stripe characterized by a series of notches on each side, usually, a pair on the vertex and pronotum and two pairs on tegmina one about middle of clavus and another at cross-veins. This stripe composed of a large golden-yellow triangle with dark center occupying most of vertex from just inside of eyes to apex, disc of pronotum which is dark red to brown, clavi and posterior portion of tegmina. Clavi dark red turning to brown on inner margin. Corium with a broad dark red stripe arising about opposite middle of clavus and following Cu to cross-veins. An orange stripe beginning behind eyes, changing to a lemon yellow one, follows costal margin to cross-veins. Apex of tegmina dusky with fuscous spots just before the cross-veins. Venter dark with mesosternum darker.

Genitalia. (Pl. I, Fig. 17.)

Styles with medium foot; base slightly curved; heel prominent; anterior point about a right angle; posterior point almost as long as base of foot, narrow, sides coverging. Pygofer hook flattened on outer curve. Oedagus of medium length, slightly curved in lateral view; ending in a flattened and laterally widened lip which turns up at right angles to shaft.

Holotype, male, Scott Co., Ark., Aug. 24, 1928; L. D. Beamer.

Allotype, female, Scott Co., Ark., Aug. 24, 1928; R. H. Beamer.

Paratypes, 27 males and 46 females same data.

This species will be confused externally with *lawsoniana* Bak. and *stolata* McA. It may be separated from the former by having vertex marked in yellow instead of red and from the latter by red dorsal stripe instead of a black one.

All of the specimens were swept from scrubby willows growing along a rocky river bed. They were associated with *E. rosa* Rob.

19. **Erythroneura rufostigmosa** var. **subnubila** n. var.

General ground color opaque yellowish white; marked with a median dorsal stripe arising on apex of vertex and widening to tips of tegmina; characterized by a pair of notches on each side, vertex and pronotum, more pronounced than in *rufostigmosa*, and two pairs on tegmina less pronounced. A triangular orange mark occupying vertex from just inside eyes to apex with a median lighter dash surrounded by fuscous. In some specimens this triangular area has a red border with fuscous center. Disc of pronotum fuscous bordered by red with a semblance

of the median white dash, lateral margins yellowish white. Scutellum fuscous with trace of median white vitta. Clavus fuscous with tendency to red vitta in outer margin. Coria dark, from opposite middle of clavus, between Cu and inner margin to cross-veins. Beyond cross-veins fuscous. Orange vitta arising at base of eye extends on costa to costal plaque. Cross-veins light tinged with orange or red in some specimens. Venter of abdomen and mesosternum fuscous.

Genitalia. Identical with that of *rufostigmosa.*

Holotype, male, Douglas Co., Kans., 1927; R. H. Beamer.

Allotype, female, Douglas Co., Kans., 1928; R. H. Beamer.

Paratypes from the following localities: Anderson Co., Kans., 2 females and 6 males, 1927; Leavenworth Co., Kans., 18 females and 17 males, 1928; Cherokee Co., Kans., 2 males, 1927; Douglas Co., Kans., 21 females and 8 males, 1927; R. H. Beamer; Lawrence Co., Ill., 39 females and 29 males; Johnson Co., Ill., 3 females and 13 males; Wabash Co., Ill., 1 female and 2 males, R. H. Beamer and P. W. Oman.

This variety differs from *rufostigmosa* in having the red vittæ bound solidly together by fuscous. Externally they appear far more different than other species that have genitalia totally unlike. According to their genitalia, however, one is just a color variety of the other.

This variety may be confused with *lawsoniana* Bak. from which it may usually be separated by the black filled orange V of the vertex.

20. **Erythroneura oculata** McA.

Erythroneura oculata. Ill. Nat. Hist. Survey Bulletin, Vol. XV, Art. 11, p. 40; May 9, 1924.

A series of eight females and five males were taken in the type locality on August 3, 1928. A female was compared with the Holotype and found to agree in every respect except in red coloring. This may be accounted for by the differences in collecting dates as the various species of Erythroneura all become darker colored and in many cases differently colored during the winter.

Genitalia. (Pl. I, Fig. 18.)

Styles simple; large heel; almost no toe. Oedagus with heavy shaft and large bulbous heart-shaped head. Pygofer hook single, sword-shaped, rather irregular in outline.

Allotype, male. General ground color greenish yellow. Vertex with a dusky spot on apex with two velvety black round spots separated by almost one of their diameters, just posterior to it. Slight indication

of a dusky median vitta. Pronotum with disc darker, slightly fumose with a tendency to transverse row of darker spots anteriorly. Scutellum with a velvety black spot in basal angles. Tegmina fumose with lighter spots much as in ***vulnerata*** Fitch. Costal plaque greenish yellow with a darker cloud near middle. A darker spot at each end. Cross-veins whitish. Apical cells darker. Venter fumose, mesosteruum very dark; face dusky mesally with a velvety black spot, slightly smaller than those on vertex, located in front of each eye. Eyes with a dark spot in posterior corner.

21. **Erythroneura quadricornis** n. sp.

General ground color greenish yellow. Vertex with two circular, velvety black spots separated by a distance about equal to one of their diameters. A trace of a smoky median line. Pronotum with disc fumose, anterior line of this darkened area in shape of a three which is much darker than the rest. Scutellum with a round, velvety black dot in each basal angle. Tip slightly darkened in some specimens. Tegmina slightly smoky throughout. Veins light. Costal plaque yellow. Venter more or less fumose with the mesosternum much darker. A darkened spot in posterior corner of each eye.

Genitalia. (Pl. I, Fig. 19.)

Styles simple; large heel; almost no toe. Pygofer with three processes and an additional large seta which often is broken off in dissection. Oedagus broad in lateral view, ending in a recurving forked tip. A pair of diverging processes arise at base of shaft extending toward apical ones.

Holotype, male, Cameron Co., Texas, August 3, 1928; R. H. Beamer.

Allotype, female, same data.

Paratypes, 6 males and 2 females, same data.

This species may easily be mistaken for *apacha* Bak. but may be separated from that species by the much shorter distance between the black spots of the vertex and by the shape of the oedagus and its processes and the extra process on the pygofer.

22. **Erythroneura apacha** Bak.

Typhlocyba bipunctata Gillette. Proc. U. S. Nat. Mus., Vol. XX. p. 751; 1898.
Erythroneura apacha Baker. Phil. J. Sci., Vol. 27, p. 537; 1925.

Genitalia. (Pl. I, Fig. 20.)

Styles simple; large heel; almost no toe. Pygofer with two processes and a large seta. Oedagus long, shaft heavy, ends in a pair of recurved processes. Another pair of processes arises at base of shaft extending almost to its tip.

Dissection made from a light colored male. Victoria, Texas, July 29, 1903.

This species is close to *E. quadricornis* Beamer both externally and in male genitalia. Black velvety spots on this species are usually distinctly farther apart, twice diameter of spots, while *quadricornis* is one diameter. The male of this species has but two processes on pygofer; the other has three.

23. **Erythroneura falcata** n. sp.

General ground color semihyaline to yellowish white. Vertex with an inverted orange V; enlarged near eyes, scarcely touching them; continued on pronotum as two diverging vittæ, touching both margins, one or none; this color almost red in some specimens. Scutellum with tip orange, basal angles yellow. Tegmina with the customary three pairs of vittæ. Beyond cross-veins dusky. Color of vittæ coppery. Face orange to coppery; mesosternum dusky. Abdomen with dusky marks. Whole venter with a pinkish tinge. Spines of hind tibiæ dark.

Genitalia. (Pl. I, Fig. 21.)

Styles with foot of medium length; heel heavy; anterior point about a right angle; posterior point in shape of sickle. Oedagus of medium length, stout, with a lateral flange which ends in a cross about one-third distance from tip, with knobs on the cross-arm.

Holotype, male, Johnson Co., Ill., March 30, 1929; R. H. Beamer.

Allotype, female, same data.

Paratypes, 3 males and 8 females, Johnson Co., Ill.; R. H. Beamer and P. W. Oman.

24. **Erythroneura harpax** n. sp.

General ground color semihyaline to whitish, light parts of tegmen pruinose. Vertex with red inverted V widened to follow eye from base of vertex to margin. Pronotum with disc darker and oval red spots either side mediam line not touching either margin. Tip and basal angles of scutellum red. Tegmina with usual vittæ, coppery colored, margins indefinite; dark abdomen showing through to give a darkened effect in claval area; dusky from tip of clavi outward. Some specimens appear slightly dusky all over. Face orange red, mesosternum dark; venter of abdomen dark, tinged with red.

Genitalia. (Pl. I, Fig. 22.)

Style with foot heavy; base sinuate near toe; heel very large, protruding posteriorly; anterior point very small, a mere angle; posterior point very long and narrow, sickle-shaped. Oedagus of medium length, bent dorsally near tip, with a pair of processes strongly arched ventrally, ending near outer portion of bend in oedagus; in ventral view these processes separate at base abruptly, then follow shaft to again diverge astride the shaft at their tip. Oedagus ends in a laterally flattened wedge-shaped tip.

Holotype, male, Nashville, Tenn., Dec., 1927; R. H. Beamer.

Allotype, female, same data.

Paratypes, two males and one female same data; 2 males, Washington, D. C., W. L. McAtee.

This species looks like *E. kanza.* Rob. and *E. varia.* McA. but is different from either in some particulars of the male genitalia. From *varia* it differs in styles, although resembling it in oedagus. From *kanza* it differs in oedagus, although resembling it in styles.

25. **Erythroneura cotidiana** n. sp.

General ground color semihyaline to opaque yellowish white. Vertex with reddish-orange inverted V; arms of V enlarged basally; continued across pronotum as diverging vittæ. Scutellum reddish orange. Coria with usual three pairs of oblique stripes of same color. Between arms of V on vertex brownish, continuing between diverging vittæ of pronotum, gradually growing darker across pronotum which with the dark abdomen, showing through semihyaline tegmina, gives the insect quite a darkened appearance. Dusky spots before cross-veins. From cross-veins to tip fumose. Face orange. Mesosternum black. Venter of abdomen partially darkened.

Genitalia. (Pl. II, Fig. 23.)

Male style with medium foot; base curved; heel large; anterior point about a right angle, projecting outward; posterior point extending at right angle to foot, long, (almost length of foot), almost parallel-sided. Oedagus of medium length; straight, with a short, sharp, laterally turning spine near tip

Holotype, male, Tuskahoma, Okla., May 23, 1928; R. H. Beamer.

Allotype, same data.

Paratypes, five males and two females; Plummers Island, Maryland, January 13, 1929; W. L. McAtee.

26. **Erythroneura cuneata** n. sp.

General ground color semihyaline to opaque white, tinged with greenish yellow. Markings lemon yellow in summer specimens, orange in hibernation. Vertex with the usual inverted V very faint in summer specimens, well marked in overwintering ones. Usual vittæ of pronotum faintly marked, disc darker. Scutellum darker yellow, almost orange. Tegmina glistening, oblique stripes faint, in usual place. Beyond cross-veins more or less dusky. Dorsum of abdomen dark. Venter mostly light but with some dark markings.

Genitalia. (Pl. II, Fig. 24.)

Styles with foot of moderate length; heel with small projecting angle. Anterior point short, projecting out and anteriorly; posterior

point about six times as long and almost parallel-sided; oedagus short, rather stout, curved, no processes at base, ending in a laterally flattened wedge-shaped tip.

Holotype, male, Le Flore Co., Oklahoma, May 21, 1928; R. H. Beamer.

Allotype, female, same data.

Paratypes, 3 males and 8 females, same data.

27. **Erythroneura diffisa** n. sp.

General ground color yellowish white to semi-hyaline on tegmina. Vertex with orange inverted V. Sides of V enlarged near the eyes but not touching them. Pronotum with two orange vittæ of varying width, usually reaching both margins and diverging from front to back. Scutellum mostly orange with median club-shaped white area. Tegmina with three pairs of oblique vittæ. The orange pair on clavi broad; two pairs on coria either lemon yellow or orange. Between corial stripes semihyaline. Beyond cross-veins slightly dusky. Abdomen with some dark markings. Mesosternum practically without dark color.

Genitalia. (Pl. II, Fig. 25.)

Style with foot long; heel marked; base almost straight; anterior point one-half length of posterior and of about same width at base; posterior point forming more than a right angle at base. Oedagus with straight, heavy shaft, ending in a flattened tip, with two lateral processes arising just before tip and bending out at right angles, almost flush with tip.

Holotype, male, Douglas Co., Kans., 1927; R. H. Beamer.

Allotype, female, Douglas Co., Kans., 1928, R. H. Beamer.

Paratypes, 24 males, Douglas Co., Kans., R. H. Beamer; 1 male, Riley Co., Kans., R. H. Beamer; 1 female, Anderson Co., Kans., R. H. Beamer; 3 males, Douglas Co., Kans., P. B. Lawson; 2 males, Cherokee Co., Kans., R. H. Beamer; 2 males, Nashville, Tenn., R. H. Beamer; 7 males, from *Gleditsia*, Le Flore Co., Okla., R. H. Beamer; 21 females, from *Gleditsia*. Le Flore Co., Okla., R. H. Beamer; 10 females, same host, Douglas Co., Kans., R. H. Beamer; 1 male, Anderson Co., Kans. P. W. Oman.

This species has been colected on Black Locust in both Kansas and Oklahoma in both yellow and orange-striped forms. It very often has one orange stripe and 2 lemon yellow ones.

28. **Erythroneura torra** Rob.

Erythroneura torra. Can. Ent., Vol. LVI, No. 7, p 155; 1924.

The character that was supposed to be diagnostic of this species (one orange stripe and one or two yellow) is quite variable. The genitalia are much better.

Genitalia. (Pl. II, Fig. 26.)

Male. Style with medium foot; heel prominent; base of foot straight; anterior point slightly less than a right angle, short; posterior point narrow, sharp, as long as width of foot at toe, inner margin forming a right angle with base of foot. Oedagus long, straight, slightly enlarged toward tip with lateral processes just before tip, these may be quite broad and blunt or very thin and spine-like. Some variation is apparently present here. Even so the genital characters are far more reliable than external ones.

29. **Erythroneura quadrata** n. sp.

General ground color white. Vertex with orange inverted V; arms of V enlarged at tip, not or barely touching eyes; continued almost across pronotum with inner margins nearly parallel, and outer diverging posteriorly. Scutellum orange to yellow except median white bar which extends almost to tip. Tegmina with two parallel vittæ of about equal width. Some dusky spots just before cross-veins, beyond dusky. Abdomen more or less dusky. Mesosternum black.

Genitalia. (Pl. II, Fig. 27.)

Styles with medium foot, short heel; anterior point short and blunt with different angle from posterior. Posterior point at right angles to foot, of medium length, slender, sides converging. Oedagus heavy, moderately long, flattened from dorsal view, slightly widened just before tip, ending in a smaller almost square-sided tip.

Holotype, male, Douglas Co., Kansas, 1927; R. H. Beamer.

Allotype, female, Douglas Co., Kansas, 1928; R. H. Beamer.

Paratypes, 13 males, Douglas Co., Kansas; 3 males, Le Flore Co., Oklahoma; 6 females, Douglas Co., Kansas; 2 females, Le Flore Co., Oklahoma; 1 male, Shawneetown, Illinois; R. H. Beamer.

This species was collected on locust in Oklahoma.

30. **Erythroneura parvispicata** n. sp.

General ground color semihyaline to white. Vertex with narrow orange inverted V touching eye at base; continuing across pronotum as two diverging stripes. Scutellum more or less orange. Tegmina with usual orange oblique vitta, definite in outline, ending at cross-veins. Three more or less dusky spots before cross-veins; slightly dusky beyond. Abdomen more or less darkened also mesosternum. Spines on hind tibiæ dark.

Genitalia. (Pl. II, Fig. 28.)

Style with medium foot; heel prominent in comparison to toe. Foot narrowed to toe with short anterior point projecting laterally only. Posterior point very narrow and short, projecting latero-posteriorly. Oedagus long, curved dorsally, no projections, ending in a much narrowed tip.

Holotype, male, Polk Co., Arkansas, February 21, 1928; R. H. Beamer.

Allotype, female, Le Flore Co., Oklahoma, May 21, 1928; R. H. Beamer.

Paratypes, seven males and eight females, same localities.

31. **Erythroneura coarctata** n. sp.

General ground color yellowish white. Vertex with an orange inverted V; arms greatly widened touching eyes slightly or not at all; continued on pronotum as two almost parallel vittæ which usually do not touch either margin. Scutellum uniformly yellow or orange. Tegmina with three pairs of vittæ. Large dusky areas before cross-veins and dusky beyond them. Face lemon yellow to orange. Mesosternum dark. Abdomen more or less dark. The dark of the abdomen shows through the tegmina in such a manner as to give the dorsal view of the insect a rather two-spotted appearance without magnification.

Genitalia. (Pl. II, Fig. 29)

Styles with narrow foot of medium length; prominent heel; anterior point long, narrow, at an acute angle to foot; posterior point shorter and broader, in same line as anterior point, their outer faces forming almost a straight line. Oedagus from lateral view short, curved, with tip compressed and wedge-shaped and a pair of sharp, short, processes or spines arising on the sides just before opening

Holotype, male, Cherokee Co., Kansas, 1927; R. H. Beamer.

Allotype, female, same data.

Paratypes, 9 males and 5 females, Cherokee Co., Kansas; R. H. Beamer.

32 **Erythroneura aenea** n sp.

General ground color yellowish white. Coloring of over-wintering forms coppery, of summer forms lemon yellow. Vertex with inverted V with sides enlarged at tip but not or barely touching eyes. Pronotum with two broad vittæ slightly diverging and usually not touching either margin. Scutellum with orange tip, yellow basal angles and a median longitudinal white bar reaching anterior margin. Tegmina with oblique coppery or lemon-yellow vittæ with indefinite margins. One pair occupying most of clavi. Sometimes with dusky blotches before cross-veins and more or less dusky beyond. Winter forms more or less pruinose over all. Summer forms with a greenish-yellow appearance. Abdomen with more or less dark markings. Mesosternum almost light to very dark.

Genitalia. (Pl. II, Fig. 30.)

Style with medium foot; base straight; small heel; anterior point narrower than posterior, about half as long as base of foot; posterior point same length, wider at base. Oedagus large, straight and broad from dorsal view, tip tapering to a bifid end the parts of which bend out at right angles.

Holotype, male, Douglas Co., Kansas, 1927; R. H. Beamer.

Allotype, female, Douglas Co., Kansas, 1928, black locust; R. H. Beamer.

Paratypes, 1 male, Cherokee Co., Kansas; 1 male, Nashville, Tenn.; 3 males and 1 female, Le Flore Co., Oklahoma; 6 males and 2 females, Douglas Co., Kansas; R. H. Beamer.

This species was collected frequently from *Gleditsia*.

33. **Erythroneura gleditsia** n. sp.

General ground color semihyaline to yellowish white. Vertex with yellow inverted V; widened at base of arm to almost touch eyes; continued across pronotum as two slightly diverging yellow vittæ; basal angles, lateral margins and tip of scutellum yellow; tegmina with usual three pairs of lemon-yellow (summer specimens) oblique stripes, otherwise almost hyaline; dorsum of abdomen black; venter of abdomen more or less black and mesosternum fuscous.

Genitalia. (Pl. II, Fig. 31.)

Styles with foot long and narrow; heel well marked; anterior point wide at base, about half as long as posterior point, projecting out and slightly anteriorly; posterior point broad, its inner side forming an even curve with base of foot, its outer an obtuse angle with anterior point. Oedagus long, almost straight with apical fifth bent dorsally

Holotype, male, Le Flore Co., Oklahoma, May 24, 1928; R. H. Beamer.

Allotype and one Paratype, same data. Taken on honey locust.

34. **Erythroneura fulvocephala** Rob.

Erythroneura fulvocephala. Can. Ent., Vol. LVI, No. 7, p. 155; 1924.

Genitalia. (Pl. II, Fig. 32.)

Styles with medium foot; heel medium, about as in *obliqua* (Say); anterior point about a right angle; posterior point narrow, about two-thirds length of base of foot, sides converging, shorter than in *obliqua.* Oedagus curved dorsally in lateral view, with a pair of processes arising above base of shaft and extending about half its length.

This species may be separated from *obliqua* by its dark venter, by the curved oedagus in lateral view, by the processes arising away from base of oedagus and by the posterior point of style being shorter.

35. **Erythroneura penenoeva** n. sp.

General ground color semihyaline to opaque white. An irregular-sided yellow inverted V on vertex. Two posteriorly diverging yellow vittæ on pronotum. Scutellum usually fuscous, in some specimens basal angles with black spots, remainder brown. The usual three yellow or orange vittæ on tegmina, following Cu from about opposite middle of clavus to cross-veins. Three dusky spots before cross-veins. Apical cells dusky. Venter of abdomen dark. Mesosternum and dorsum of abdomen darker. Face golden yellow.

Genitalia. (Pl. II, Fig. 33.)

Styles with short foot; moderate heel; anterior point about a right angle; posterior point about as long as foot, sides converging. Oedagus of medium length, curved dorsally with a pair of apically thickened processes arising slightly above base of shaft, paralleling it, and diverging astride the shaft at their tip.

Holotype, male, Douglas Co., Kansas, June, 1926; R. H. Beamer.

Allotype, female, same data.

Paratypes, 26 males and 6 females, Douglas Co., Kans.; 3 males and 6 females, Anderson Co., Kans., 1927; 26 males and 16 females, Leavenworth Co., Kans., 1928; R. H. Beamer.

This species will be confused with *E. noevus* (Gill.). It may be separated from it by having a dark colored abdomen, a darker mesosternum and by the male genitalia.

36. **Erythroneura noevus** (Gill)

Typhlocyba obliqua var *noevus* Gillette. Proc. U. S. Nat. Mus., Vol. XX, p. 757; 1898.

General ground color pearly white. Vertex with bright red inverted V touching eyes at margin. V continued across pronotum as two diverging red vittæ. Posterior part between these vittæ dusky, remainder of pronotum pearly white. Scutellum dusky, the posterior angles usually darker. Tegmina marked with oblique red vittæ; claval vittæ widest, beginning at humeral angle, and following claval suture to tip. A pair of corial vittæ arise opposite anterior end of costal plaque and follow Cu to cross-veins. Costal margin from humeral angle to costal plaque with a narrow red vitta. Beyond cross-veins often slightly dusky. Abdomen pearly white, face orange. Mesosternum either almost entirely fuscous or with at least a fuscous spot on either side.

Genitalia. (Pl. II, Fig. 34.)

Style with medium foot; heel moderate, with slight hook to point; base almost straight; anterior point almost a right angle; posterior point almost as long as foot, rather broad, almost parallel-sided. Oedagus with short slightly curved shaft, a pair of processes arising above base of shaft and diverging at a wide angle. In lateral view a wide space is visible between base of oedagus and base of processes.

37. **Erythroneura obvia** n. sp.

General ground color semihyaline to opaque white. Vertex with inverted orange V with an outward projecting tooth near eye. Pronotum crossed with two diverging orange stripes. Scutellum with tip and basal angles orange. Tegmina with usual orange oblique stripes, usually more or less dusky spots before cross-veins. Beyond cross-veins more or less dusky. Mesosternum dark, also more or less of abdomen.

Genitalia. (Pl. II, Fig. 35.)

Style with medium foot; large projecting heel; anterior point about a right angle; posterior point long and narrow; sides almost parallel. Base of foot and inner margin of posterior point forming almost a semicircle. Oedagus of medium size, rather stout at base with 2 processes arising at base and curving out near tip; ending in a laterally flattened dorsally curving tip.

In Kansas specimens, the base of foot is nearer straight and the posterior point is wider.

Holotype, male, Polk Co., Arkansas, August 21, 1928; R. H. Beamer.

Allotype, female, same data.

Paratypes, 8 males, Cherokee Co., Kansas, August 31, 1929, R. H. Beamer; 3 males, Scott Co., Arkansas, August 21, 1929, L. D. Beamer; 2 males, Le Flore Co., Oklahoma, May 21, 1928, R. H. Beamer; 5 males, Nashville, Tenn., December, 1927, R. H. Beamer; 1 male, Anderson Co., Kansas, P. W. Oman.

38. **Erythroneura rubens** n. sp.

General ground color semihyaline to opaque whitish. Vertex with bright red, inverted V; arms widened near eyes, continued across pronotum as bright red diverging stripes. Tip of scutellum and margins of basal angles at least, bright red, sometimes a dark spot in either basal angle. Tegmina glistening, with typical oblique bright red stripes on clavus, Cu and costa. Costal plaque almost yellow. Slightly before and beyond cross-veins dusky. Dorsum of abdomen dark. Face with anterior red margin, remainder brownish yellow, mesosternum same color. Venter of abdomen black. Lateral margins of thorax bright red.

Genitalia. (Pl. II, Fig. 36.)

Style with narrow, rather small foot; base straight; heel small, distinct; anterior point long and narrow, projecting out and anteriorly; posterior point basally about same width, half as long and projecting inward almost in a line with anterior point. Oedagus of medium length, curved in lateral view with a pair of processes arising at base of shaft and reaching slightly over half its length.

Holotype, male, Gallatin Co., Ill., March 31, 1929; R. H. Beamer.

Allotype, female, Wabash Co., Ill., March 31, 1929; P. W. Oman.

Paratypes, 2 males, White Co.; Ill., 4 males, Lawrence Co., Ill.; 5 females, Lawrence Co., Ill.; 3 females, Wabash Co., Ill.; 4 females, White Co., Ill.; collected by R. H. Beamer and P. W. Oman.

In the color of the markings this species resembles *E. noevus* var. *parma* McA. but is easily separated from it by its dark abdomen.

39. **Erythroneura rubrataeniensis** n. sp.

General ground color milky white. Vertex and pronotum with even-sided, inverted, orange V; outer edges of V touch eyes; continued across pronotum as even-sided slightly diverging orange stripes and sometimes continued over margin of vertex connecting with face. Scutellum orange with an elongated basal white spot and two golden yellow spots in each basal angle Tegmina with three oblique orange vittæ. Claval stripe broadest, occupying almost entire clavus. Costal plaque lemon yellow. Cross-veins often red; beyond more or less dusky. Face orange. Abdomen and mesosternum dusky.

Genitalia. (Pl. II, Fig. 37.)

Styles with foot short; base straight; heel medium; anterior point sharp, about one-half as thick and about as long as posterior point. Oedagus with straight heavy shaft, a pair of processes arising at base taper rapidly, ending in slender, sharply diverging points near end of oedagus.

Holotype, male, Douglas Co., Kansas; R. H. Beamer.

Allotype, female, same data.

Paratypes, 14 males, Cherokee Co., Kans.; 22 males, Douglas Co., Kans.; 7 males, Anderson Co., Kans., R. H. Beamer; 30 males, Johnson Co., Ill., R. H. Beamer and P. W. Oman; 2 males, Wabash Co., Ill., P. W. Oman; 19 females same localities and collectors.

The prominent even-sided, inverted V crossing vertex and pronotum usually makes this species evident.

40. **Erythroneura sagittata** n. sp,

General ground color semihyaline to opaque white. Vertex with bright, even-sided, inverted orange V with or without a slight bulge on outside near eye; extending across pronotum as two posteriorly widening vittæ. Scutellum mostly orange. Tegmina with usual oblique stripes. Cells before and after cross-veins dusky forming an indefinite dark cross band. Dorsum of abdomen black showing through tegmina as a dark cross band; thus to the unaided eye this species appears to have two dark cross bands separated by a lighter one. Face reddish brown, darker posteriorly. Venter dark.

Genitalia. (Pl. II, Fig. 38.)
Styles with foot rather short; base curved to meet posterior point; heel pronounced; anterior point long, narrow, projecting out in a direct line with base of foot; posterior point, at base, about four times as wide as anterior point and somewhat longer. Oedagus of medium length, widened near base into an arrow-shaped process, almost as wide as oedagus is long, with saw teeth on antero-lateral margins. Two processes arise at base of shaft on ventral side and extend to tip where they are widened slightly and have irregular teeth. Oedagus narrows suddenly at tip and ends in a very short cross-bar.

Holotype, male, Gallatin Co., Ill., March 31, 1929; R. H. Beamer.

Allotype, same data.

Paratypes, 33 males, Gallatin Co., Ill., R. H. Beamer and P. W. Oman; 3 males, Johnson Co., Ill., R. H. Beamer; 49 females, same data.

This species can usually be separated from *E. funesta* by the cross-banded appearance of the tegmina and from all others by the male genitalia.

41. • **Erythroneura funesta** n. sp.

General ground color semihyaline on tegmina to opaque white on head. Vertex with inverted even sided, orange V; continued across pronotum as two vittæ whose inner margins are parallel and whose outer ones diverge. Scutellum orange except an antero-median rectangular white spot. Tegmina with customary oblique stripes, claval stripes broad almost covering clavi, corial stripes also broad giving the whole insect a red appearance. From just before cross-veins to tip dusky. Venter dark.
Genitalia. (Pl. II, Fig. 39.)
Styles with medium foot; medium heel; curved base; narrow laterally projecting anterior point and heavy (5 to 6 times as broad as anterior) posterior point. Oedagus of medium length, almost straight, slightly narrowed at tip, and ending in a short flattened cross-bar. Two processes arise ventrally at base of shaft, extend almost length of shaft and end in lanceolate tips.

Holotype, male, Gallatin Co., Ill.; R. H. Beamer.

Allotype, female, same data.

Paratypes, 6 males, Gallatin Co., Ill., R. H. Beamer and P. W. Oman; numerous females same data.

This species occurs with *E. sagittata.* Usually it may be separated from that species by the banded appearance of the former and always by the queer arrow-shaped oedagus of the latter.

42. **Erythroneura plena** n. sp.

General ground color semihyaline to opaque yellowish white. Vertex with orange inverted V, even sided, enlarged near eyes and extending across pronotum as two enlarging diverging even-sided stripes. This species is characterized by its even-sided markings of vertex and pronotum. Scutellum with extreme tip and basal angles orange. Tegmina with the usual 3 pairs of oblique vittæ orange. Fuscous spots before cross-veins. Beyond hyaline to slightly fumose. Face orange, mesosternum and venter black.

Genitalia. (Pl. II, Fig. 40.)

Style with foot heavy basally; base straight; heel not large but projecting sharply inward; anterior point sharp, about one-third as long as posterior, extending mostly anteriorly, a slight outward trend; posterior point twice as broad, inner margin at right angles with base of foot, sides tapered to sharp point, about twice as long as width at base. Oedagus heavy; of medium length; almost straight in lateral view: dorsal side sinuate near middle and evenly rounded to tip, as large or larger just before tip as at base. Two processes arise just below base of shaft curving downward near their middle and back to tip of shaft. Slightly swollen and toothed near their middle.

Holotype, male, Cherokee Co., Kans., August 21, 1927; R. H. Beamer.

Allotype, female, same data.

Paratypes, 4 males and 1 female, Cherokee Co., Kans.; 3 males and 6 females, Lawrence Co., Ill., R. H. Beamer.

This species resembles *rubrataeniensis* in external appearance but it may be distinguished by smaller size, clearer tegminal tips and by the genital characters.

43. **Erythroneura stolata** McAtee.

Erythroneura obliqua var. *stolata* McAtee. Trans. Am. Ent. Soc., Vol. XLVI, p. 279; 1920.

General ground color yellowish white. Dorsum marked by a median longitudinal fuscous stripe which begins on apex of vertex and grows progressively wider as it proceeds posteriorly. On tegmina this occurs in three steps, one near middle of clavus, second on corium about even with anterior end of costal plaque and the third at the cross-veins where it widens including all of tegmina to M_{1+2}. Costa orange from humeral angle to costal plaque. Body creamy white. Face tinged with orange.

Genitalia. (Pl. II, Fig. 41.)

Styles with medium foot; heel large; anterior point almost as long as base of foot; curved; almost parallel sided. Oedagus very long, curved upward into a huge arc, shaft tapering from base to tip.

Allotype, male, Douglas Co., Kansas, January 1, 1926; R. H. Beamer.

The type series of this species does not contain a male so the above mentioned specimen is designated as the Allotype. A male of this species determined by McAtee from Iowa and an immature male from Glen Echo, Md., from his collection were dissected and found to agree with the Kansas specimen in every respect.

This species externally may be confused with *E. rufostigmosa* var. *subnubila* from which it can be separated by the fact that the latter has red oblique stripes on dorsum filled in with fuscous, while *stolata* is entirely black.

44. **Erythroneura albescens** n. sp.

General ground color semihyaline to opaque white. Vertex with an orange inverted V, enlarged near posterior margin and just barely touching eye, continued entirely across pronotum as diverging vittæ. Tip of scutellum orange, basal angles yellow. Tegmina with three pairs of oblique stripes. Some specimens with dusky spots before cross-veins. Beyond cross-veins slightly dusky. Face with an orange band just below vertex, remainder yellowish, body stramineous. Posterior tibiæ with row of black spines.

Genitalia. (Pl. II, Fig. 42.)

Styles with medium foot; medium heel; anterior point about a right angle; a very long slender, slightly tapering posterior point curving out near its middle. Oedagus, in lateral view, of medium length; curved so much that with its base it forms a large U.

Holotype, male, Cherokee Co., Kansas, 1928; R. H. Beamer.

Allotype, female, Johnson Co., Ill., March 30, 1929; R. H. Beamer.

Paratypes, 10 males, Johnson Co., Ill., March 30, 1929, R. H. Beamer; 7 males, Cherokee Co., Kans., August 31, 1927, R. H. Beamer; Le Flore Co., Oklahoma, 1 male, May 24, 1928, R. H. Beamer; 1 male, Wabash Co., Ill., March 30, 1929; 2 females, Johnson Co., Ill., March 30, 1929, R. H. Beamer.

45. **Erythroneura cruciformis** n. sp.

General ground color milky white. Vertex with large inverted orange V, broadly touching eyes, may be connected at apex with color on face; continued on pronotum as a pair of sharply diverging vittæ which do not reach posterior margin. Tip of scutellum orange, basal angles yellow. Tegmina with three pairs of vittæ. Beyond cross-veins slightly dusky. Face and bar behind eyes orange. Remainder of body stramineous.

Genitalia. (Pl. II, Fig. 43.)

Styles with medium foot; medium heel; anterior point about a right angle; posterior point long and broad, oedagus from ventral view short and heavy, with a large diamond-shaped cross-bar slightly beyond middle. Outer tips of diamond narrow and bent dorsally in an even curve.

Holotype, male, Douglas Co., Kansas, 1927; R. H. Beamer.

Paratypes, 13 males, Douglas Co., Kansas, 1927, R. H. Beamer; 6 males, Anderson Co., Kansas, 1927, R. H. Beamer; 3 males, Cherokee Co., Kansas, 1927, R. H. Beamer; 1 male, Polk Co., Arkansas, 1928, R. H. Beamer; 2 males, Anderson Co., Kansas, P. W. Oman; 1 male, Johnson Co., Illinois, R. H. Beamer.

46. **Erythroneura spatulata** n. sp.

General ground color pearly white. Vertex with bright orange, inverted V, arms enlarged but scarcely touching eyes; continued across pronotum as slightly enlarging, slightly diverging vittæ. Tip of scutellum and margins of basal angles orange, remainder of basal angles yellow. Coria with usual three pairs of oblique, orange stripes. Three dusky spots before cross-veins, fumose beyond. One row and sometimes a few in second row of black spines on hind tibiæ. Face orange, sternum yellow, venter of abdomen stramineous tinged, with orange on margins of sclerites.

Genitalia. (Pl. II, Fig. 44.)

Styles with medium foot; base sinuate; heel large; anterior point small, about a right angle; posterior point about as long as foot, sides almost parallel, narrow, slightly sinuate laterally. Oedagus long, slightly curved dorsally, ending in a dorso-ventrally flattened spatulate tip, wider than shaft. A pair of processes arising and ending just before tip in lateral out-curvings.

Holotype, male, Johnson Co., Ill., March 30, 1929; R. H. Beamer.

Allotype, female, Johnson Co., Ill., March 30, 1929; P. W. Oman.

Paratype, male, Johnson Co., Ill., March 30, 1929; R. H. Beamer.

47. **Erythroneura tenuispica** n. sp.

General ground color ivory white. Vertex with inverted orange V; tips of V widened scarcely touching eyes, continuing almost across pronotum as two, rather narrow, slightly diverging orange stripes. Scutellum with tip orange, basal angles yellow. Tegmina with usual 3 pairs oblique orange stripes, rather narrow and well marked, beyond cross-veins more or less fumose, at least nearly opaque. Venter stramineous, face yellow or pinkish.

Genitalia. (Pl. II, Fig. 45.)

Style with medium foot and heel; base almost straight; anterior point about a right angle; posterior point almost as long as foot, sinuate on inner margin, sides nearly parallel, ending in a rounded tip. Oedagus rather long, heavy at base, curved; a sharp lateral spine either side just before tip.

Holotype, male, Douglas Co., Kansas, 1927; R. H. Beamer.

Paratypes, 7 males, Douglas Co., Kansas, 1927; R. H. Beamer.

48. **Erythroneura volucris** n. sp.

General ground color semihyaline to white, tinged anteriorly with yellow. Vertex with narrow, inverted, orange V, arms of V enlarged near eyes but scarcely touching them, continued across pronotum as two parallel-sided, diverging, orange vittæ. Scutellum with basal angles yellow, tip orange. Coria with usual three oblique vittæ, rather narrow but definite. Three dusky spots before cross-veins. Slightly fumose beyond. Face orange, sternum yellow, venter of abdomen stramineous. One row of spines on hind tibia brown.

Genitalia. (Pl. II, Fig. 46.)

Style with short, heavy foot; base straight; heel moderate; anterior point just a right angle; posterior point long (almost as long as base of foot), sharp pointed. Oedagus moderately long, dorso-ventrally flattened at tip ending in a narrow short cross bar, usually a bump on either side of shaft about three-fourths distance to tip. Pygofer hooks shape of a bird's head, very flat, sometimes with sinuate apex.

Holotype, male, Anderson Co., Kans., November 29, 1927; R. H. Beamer.

Paratypes, 14 males, Cherokee Co., Kans., 1928, R. H. Beamer; 1 male, Bowie Co., Texas, R. H. Beamer, 1928; Polk Co., Arkansas, 1 male, 1928, R. H. Beamer; Le Flore Co., Oklahoma, 3 males, R. H. Beamer; 1 male, Wabash Co., Ill., 1929, R. H. Beamer; 5 males, Johnson Co., Ill., R. H. Beamer, 1929.

49. **Erythroneura eluta** McA.

Erythroneura obliqua var. *eluta* McAtee. Trans. Am. Ent. Soc., Vol. XLVI, p. 277; 1920.

This specimen was immature, therefore practically hyaline but had it been fully developed it would no doubt have been light colored with lemon-yellow or orange vittæ on tegmina.

Genitalia. (Pl. III, Fig. 47.)

Style with short foot; medium heel; anterior point a right angle; posterior point broad and long. Oedagus medium length with a diamond-shaped process on ventral side just short of apex, ends in a narrowed dorsally bent lip. In lateral view shaft is slightly curved.

Allotype, male, Johnson Co., Ill., March 30, 1929; R. H. Beamer.

This male from Johnson Co., Ill., had the same genital characters as the immature Paratype dissected.

50. **Erythroneura hamata** n. sp.

General ground color semihyaline to white. Vertex with an orange inverted V; arms of V enlarged and touching eyes usually quite broadly; continued across pronotum as two slightly diverging vittæ. Scutellum with orange spot at tip, basal angles yellow. Tegmina with three pairs of vittæ. Costal plaque lemon yellow. Dusky spots before cross-veins. Cross-veins red in some specimens, beyond them hyaline to slightly smoky. Face yellow to pinkish with anterior margin red in some specimens. Body stramineous. Legs sometimes pink.

Genitalia. (Pl. III, Fig. 48.)

Styles with medium foot; heel medium; anterior point about a right angle; posterior point long, narrow and bent out forming, with the hollowed out base of foot, a semicircle or horseshoe. Oedagus of medium size almost straight with two processes arising at base of shaft, diverging almost at right angles and extending about two-thirds its length.

There is some variation in the thickness and shape of the posterior points of the styles. It differs from *E. infinita* mostly in the shape of the styles, shape and form of processes of oedagus and in not having a row of black spines on hind tibia.

Holotype, male, Johnson Co., Ill., March 30, 1929; R. H. Beamer.

Allotype, female, same data.

Paratypes, 15 males and 1 female, same data; 7 males, Plummers Island, Md., W. L. McAtee.

51. **Erythroneura infinita** n. sp.

General ground color semihyaline to opaque yellowish white. Vertex with bright orange, inverted V; arms of V broadly widened against eyes; continued across pronotum as diverging orange stripes. Scutellum almost all orange or yellow, a longitudinal white spot on median line at base. Tegmina with customary orange vittæ, with definite margins; slightly fumose from cross-veins to tip. Face and sides of thorax pink to orange, abdomen stramineous. Upper row of hind tibial spines usually black.

Genitalia. (Pl. III, Fig. 49.)

Style with medium foot; prominent heel; straight base; anterior point almost a right angle; posterior point broad, about as long as foot, at right angle to it, almost parallel-sided and blunt-pointed.

Oedagus with rather heavy shaft; almost straight in lateral view; several blunt teeth ventrally near basal half. Two processes arise at base, slightly diverge and curve dorsally for their entire length, extend length of shaft. Genitalia resembles that of *noevus* but may be easily separated from that species by the processes of oedagus coming off close to base of shaft while those of *noevus* come off at some distance from base.

Holotype, male, Anderson Co., Kans., November 9, 1927; R. H. Beamer.

Paratypes, 16 males, same data; 2 males, Nashville, Tenn., 1927, R. H. Beamer; 1 male, Johnson Co., Ill., 1929, R. H. Beamer.

52. **Erythroneura angularis** n. sp.

General ground color pearly white. Vertex with a bright orange inverted V with arms enlarged near each eye; continued almost across pronotum as two even-sided, narrow diverging vittæ. Scutellum with tip orange, basal angles yellow. Tegmina with usual 3 pairs of narrow oblique vittæ. Faint dusky spots just before cross-veins, beyond usually hyaline. Body white to stramineous except a narrow orange line following outer margin of face between eyes and an orange blotch immediately posterior to each eye.

Genitalia. (Pl. III, Fig. 50.)

Styles with short foot; large heel; anterior point a right angle; posterior point long, broad, curved. Oedagus in ventral view, short with a pair of processes arising at base, proceeding parallel with shaft to just beyond its middle and about two-thirds their length where they bend laterally at right angles.

Holotype, male, Anderson Co., Kansas, November 9, 1927; R. H. Beamer.

Paratypes, 8 males, Cherokee Co., Kans., 1927, R. H. Beamer; 3 males, Anderson Co., Kans., 1927, R. H. Beamer; 3 males, Douglas Co., Kans., 1927, R. H. Beamer.

53. **Erythroneura latapex** n. sp.

General ground color semihyaline to pearly white. Vertex with inverted orange V, broadened at apex of arms to touch eye about half distance to margin; continued across pronotum as two parallel-sided, slightly diverging, orange vittæ. Tip of scutellum orange, basal angles orange to yellow. Coria with usual three pairs of oblique vittæ. More or less dusky spots before cross-veins and more or less fumose beyond. Face tinged with yellowish orange, sternum yellow, venter of abdomen stramineous.

Genitalia. (Pl. III, Fig. 51.)

Styles with heavy foot; base straight; heel prominent; practically no anterior point; posterior point about as long as foot, broad as apex of foot, of uniform width, ending in tip rounded to meet inner surface,

forming less than a right angle with base of foot, inner margin almost straight. Oedagus of medium length, viewed ventrally ends in a sharp point. Two processes arise basally, almost as large as shaft, diverge in even curve from base laterally, thickened leaf-like in apical third.

Holotype, male, Douglas Co., Kans., 1927; R. H. Beamer.

Paratypes, 1 male, Anderson Co., Kansas., November, 1926, R. H. Beamer; 1 male, Nashville, Tenn., December, 1927, R. H. Beamer.

54. **Erythroneura modica** n. sp.

General ground color opaque white to hyaline. Vertex with inverted V touching eyes and extending across the pronotum as two posteriorly diverging vittæ. Scutellum more or less marked with yellow or orange. Tegmina with usual three pairs of oblique vittæ. A series of dark spots just before cross-veins. Beyond cross-veins more or less dusky. Venter stramineous.

Genitalia. (Pl. III, Fig. 52.)

Styles with foot rather small; heel rather large, projecting out sharply; toe much narrowed with small anterior point projecting out; posterior point larger, projecting in, almost forming a hook; base of foot convex, a character separating this species from almost all others. Oedagus of medium length, almost straight, with two lateral teeth or small blunt projections about three-quarters distance to tip, ending in a slightly enlarged flattened tip.

Holotype, male, Harris Co., Texas, August 13, 1928; L. D. Beamer.

Allotype, female, same data.

Paratypes, four males, same data; 9 males, Johnson Co., Ill., R. H. Beamer and P. W. Oman.

55. **Erythroneura scissa** n. sp.

General ground color semihyaline to opaque yellowish white. Vertex with yellow or orange inverted V; arms slightly widened at tip, scarcely touching eyes; continued across pronotum as narrow, diverging orange or yellow stripes. Scutellum with tip and basal angles yellow or orange. Tegmina with usual three orange or yellow oblique stripes. Venter stramineous, sometimes one row of black spines.

Genitalia. (Pl. III, Fig. 53.)

Styles with medium foot; medium heel; anterior point small, slightly less than a right angle; posterior point narrow, sharp-pointed, about half as long as base of foot and forming a right angle with it. Oedagus long; slightly curved dorsally; ending in a dorso-ventrally flattened, bifid tip. Shaft widened laterally into a blunt tooth just before opening.

Holotype, male, Scott Co., Arkansas, August 23, 1928; R. H. Beamer.

Paratypes, 8 males, Johnson Co., Ill., R. H. Beamer and P. W. Oman.

56. **Erythroneura cornipes** n. sp.

General ground color semihyaline to yellowish white. Vertex with an orange or lemon-yellow inverted V, widened and touching eyes or nearly so. Continued across pronotum as a pair of diverging vittæ. Scutellum with tip orange and angles yellow. Tegmina with three pairs of vittæ. In some specimens dusky spots appear before the cross-veins. Beyond cross-veins slightly dusky. Venter varies from stramineous throughout to bright orange on face and portions of sternum. Two specimens from Le Flore Co., Oklahoma, collected on locust, May 24, 1928, have all coloring lemon yellow.

Genitalia. (Pl. III, Fig. 54.)

Styles with medium-sized foot; heavy heel; a very blunt anterior point and a very narrow sharp posterior one. Oedagus with long curved shaft in lateral view. Widens at tip into a split hoof-like tip.

Holotype, male, Anderson Co., Kansas, November, 26, 1927; R. H. Beamer.

Allotype, female, Le Flore Co., Oklahoma, May 24, 1928; R. H. Beamer.

Paratypes, 4 males, Anderson Co., Kansas, 1927, R. H. Beamer; Douglas Co., Kansas, 7 males, R. H. Beamer, 1927; 1 male, Le Flore Co., Oklahoma, 1928; 2 males, Johnson Co., Ill., 1929, R. H. Beamer.

57. **Erythroneura malleiformis** n. sp.

General ground color pearly white to yellowish white. Vertex with inverted orange V, continued on pronotum as two parallel-sided, diverging, orange vittæ. Scutellum with tip orange, basal angles yellow. Tegmina with usual three pairs orange oblique stripes, definite but not bright as in *E. penobliqua.* Three small dusky spots or none before cross-veins, much smaller than in *E. penobliqua.* Beyond cross-veins slightly fumose. Face with anterior margin yellowish orange, remainder yellow. Venter light. One row of black spines on hind tibia, sometimes 1-3 black spines in second row.

Genitalia. (Pl. III, Fig. 55.)

Styles with foot large; heel large; base straight; anterior point broad at base, short; posterior point narrow at base, sides tapering to tip, about twice as long as anterior. Oedagus short, stout, shaft swollen near middle, ending in a dorso-ventrally flattened tip in shape of a cross-bar which is about two-thirds as long as shaft.

Holotype, male, Cherokee Co., Kans., 1928; R. H. Beamer.

Paratypes, 1 male, Cherokee Co., Kans., R. H. Beamer; 1 male, Lawrence Co., Ill., P. W. Oman.

This species externally resembles *E. penobliqua*, but can usually be separated by the much smaller black spots before cross-veins.

58. **Erythroneura tridens** n. sp.

General ground color semihyaline to opaque white. Vertex with orange inverted V, sides of V not regular and although widened at tip scarcely touch eyes. This V continued on pronotum, although broken at anterior margin, as two diverging orange vittæ which do not reach posterior margin. Scutellum with tip orange, basal angles yellow. Typical oblique stripes on tegmina. Those of clavus wide, that on Cu and costa very narrow. Slightly fumose beyond cross-veins. Anterior portion of face white, remainder orange. Abdomen stramineous.

Genitalia. (Pl. III, Fig. 56.)

Style with medium foot; heel medium; base of foot sinuate near posterior point; anterior point about a right angle; posterior point broad and short, about one-third length of foot. Oedagus long, almost straight, flanked on either side by a process which extends to tip, curving away from shaft slightly beyond middle and again at tip.

Holotype, male, Anderson Co., Kans., September 9, 1927; R. H. Beamer.

Paratypes, 7 males, Plummer's Island, Md., W. L. McAtee; 2 males, Urbana, Ill., Brownie's Woods, April 2, 1925; 1 male, Douglas Co., Kans.

This species resembles *bicornis*, but may be separated from it by the smaller inverted V on vertex and the longer processes of oedagus and the shorter posterior points.

59. **Erythroneura bicornis** n. sp.

General ground color milky white with tegmina somewhat transparent. Vertex with inverted orange V, enlarged near eyes and continuing about two-thirds way across pronotum as diverging orange vittæ. Basal angles of scutellum yellow, tip almost orange. Tegmina with three pairs of definite, rather narrow, stripes. Face more or less orange. Remainder of vertex and abdomen stramineous.

Genitalia. (Pl. III, Fig. 57.)

Styles with medium foot; heel of moderate size; base almost straight; anterior point a right angle, slightly bulging laterally; posterior point fairly broad, about two-thirds length of foot. Oedagus almost straight, of medium length, with a straight rather heavy process arising either side of shaft toward dorsal surface, diverging from shaft and ending three-fourths distance to tip.

Holotype, male, Johnson Co., Ill., March 30, 1929; R. H. Beamer.

Paratypes, 14 males, Plummer's Island, Md., W. L. McAtee; 1 male, Johnson Co., Ill., R. H. Beamer.

60. **Erythroneura obliqua** Say.

Tettigonia obliqua Say. Acad. Nat. Sci. Phila., Vol. IV, 1825, p. 342.

"Body yellowish-white, with two sanguineous lines, connivent upon the head and scutel; hemelytra white, with two sanguineous lines.

"Inhabits the United States.

"Body pale yellowish-white; head with two dilated sanguineous lines, connivent before; antennæ, seta as long as the head and thorax, dusky; thorax with two sanguineous lines; scutel with two lines and tip sanguineous; hemelytra whitish, an oblique line from the base slightly refracted on the thinner margin, and terminating behind the middle of the margin; an oblique longitudinal line on the disk, a more abbreviated, obsolete, subcostal line, and a costal line from the base to the middle of the edge, sanguineous; feet whitish; tail rosaceous.

"Length rather more than one-tenth of an inch.

"Found at Engineer Cantonment, and is also common in Pennsylvania."

General ground color semihyaline to whitish. Vertex with an inverted orange V; arms enlarged at tips to broadly touch eyes; continued across pronotum as diverging, oval-shaped vittæ, not or scarcely reaching the posterior margin. Scutellum with orange tip and more or less on basal angles. Tegmina with three pairs of orange stripes. From cross-veins to tip more or less yellowish fumose. Venter stramineous throughout.

Genitalia. (Pl. III, Fig. 58.)

Styles with medium foot; heel moderate; base straight; anterior point slightly projecting laterally; posterior point broad at base, about as long as base of foot, sides converging. Oedagus of medium size, almost straight in lateral view, narrowing slightly from base to tip, with two inconspicuous processes arising at base of shaft and extending for about half its length in contact with it.

Neotype, male, Douglas Co., Kansas, 1927; R. H. Beamer.

The name *E. obliqua* (Say) has been the recipient of many species since the time of its origin. It may be separated by the genitalia from all other forms. The male genitalia of *fulvocephala* Rob. probably look more like it than any other but *fulvocephala* has a dark colored abdomen and is a much larger species.

61. **Erythroneura magnacalx** n. sp.

General ground color pearly white. Vertex with narrow inverted V, enlarged at base of vertex but not or scarcely touching eyes; continued across pronotum as two irregular-sided, diverging vittæ. Scutellum with tip orange, basal angles yellow. Tegmina with usual three pairs

of oblique orange stripes; usually three dusky spots before cross-veins; more or less dusky beyond. Venter stramineous.

Genitalia. (Pl. III, Fig. 59.)

Style with foot medium; heel large; anterior point small, just a right angle; posterior point about as long as foot is wide at toe, sharp, rather slender. Oedagus curved in lateral view, of medium size, with a pair of processes arising at base of shaft and extending about half its length.

Holotype, male, Douglas Co., Kans., 1927; R. H. Beamer.

Paratype, 2 males, Lawrence Co., Ill., March 31, 1929, R. H. Beamer; and 1 male, Lawrence Co., Ill., March 31, 1929, P. W. Oman.

62. **Erythroneura furcillata** n. sp.

General ground color semihyaline to milky white. Vertex with an inverted V, very sharp and narrow at the base, touching the eyes and continued across the pronotum forming two exceptionally even-sided orange stripes. Scutellum with orange tip and some coloring in angles but not as much as in most species with the oblique tegminal stripes. Tegmina with three pairs of orange stripes. A row of dusky spots just anterior to cross-veins. Beyond cross-veins usually slightly dusky. Face yellowed; remainder of body stramineous. These specimens were summer forms. Winter specimens will be much darker colored.

Genitalia. (Pl. III, Fig. 60.)

Styles with short foot; heavy heel; anterior point long and sharp with its upper margin in a direct line with base of foot, posterior point wider and slightly longer with its inner margin curved, forming a right angle with the foot and the anterior point. Oedagus with moderately lengthened, heavy shaft, with two processes arising at base and ending flush with tip.

Holotype, male, Bowie Co., Texas, July 16, 1928; R. H. Beamer.

Allotype, female, same data.,

Paratypes, one male, same data and three males, Caddo Parish, La., July 19, 1928; three females, Bowie Co., Texas, and three females, Caddo Parish, La., R. H. Beamer.

63. **Erythroneura unicuspidis** n. sp.

General ground color white. Vertex with orange, inverted V, arms of V widened, touching eyes, continued across or almost across pronotum as two diverging vittæ. Scutellum with tip orange and basal angles yellow. Tegmina with usual three pairs of oblique orange vittæ; that on claval suture broadest; second following Cu to cross-veins; the third on costal margin. Often dusky spots just before cross-veins. Beyond cross-veins more or less dusky. Face may have an

orange band just beneath margin, remainder orange, pinkish or yellow. Body stramineous.

Genitalia. (Pl. III, Fig. 61.)

Styles with medium foot; heavy heel; anterior point a right angle; posterior point sharp, rather narrow, at right angles with base of foot. Oedagus heavy, almost straight, with two processes arising at base and touching its dorsal side to tip.

Holotype, male, Douglas Co., Kansas, 1927; R. H. Beamer.

Allotype, female, Johnson Co., Ill., March 30, 1929; R. H. Beamer.

Paratypes, 11 males, Douglas Co., Kans., 1927, R. H. Beamer; 1 male, Anderson Co., Kans., R. H. Beamer, 1927; 20 males, and 5 females, 1929, Johnson Co., Ill., R. H. Beamer; 1 male, Shawneetown, Ill.

64. **Erythroneura penobliqua** n. sp.

General ground color opaque white to yellowish white. Vertex with orange inverted V, arms of V enlarged at base, just touching eyes; continued across pronotum as orange vittæ whose inner margins are almost parallel and whose outer margins diverge posteriorly. Scutellum orange except small median white square at base. Tegmina with usual three pairs of quite red, oblique stripes. Three large fuscous spots before cross-veins, quite dusky from cross-veins to tip Face orange, abdomen yellowish white. Hind tibia with one row of black spines, sometimes from 1–3 black spines in second row.

Genitalia. (Pl. III, Fig. 62.)

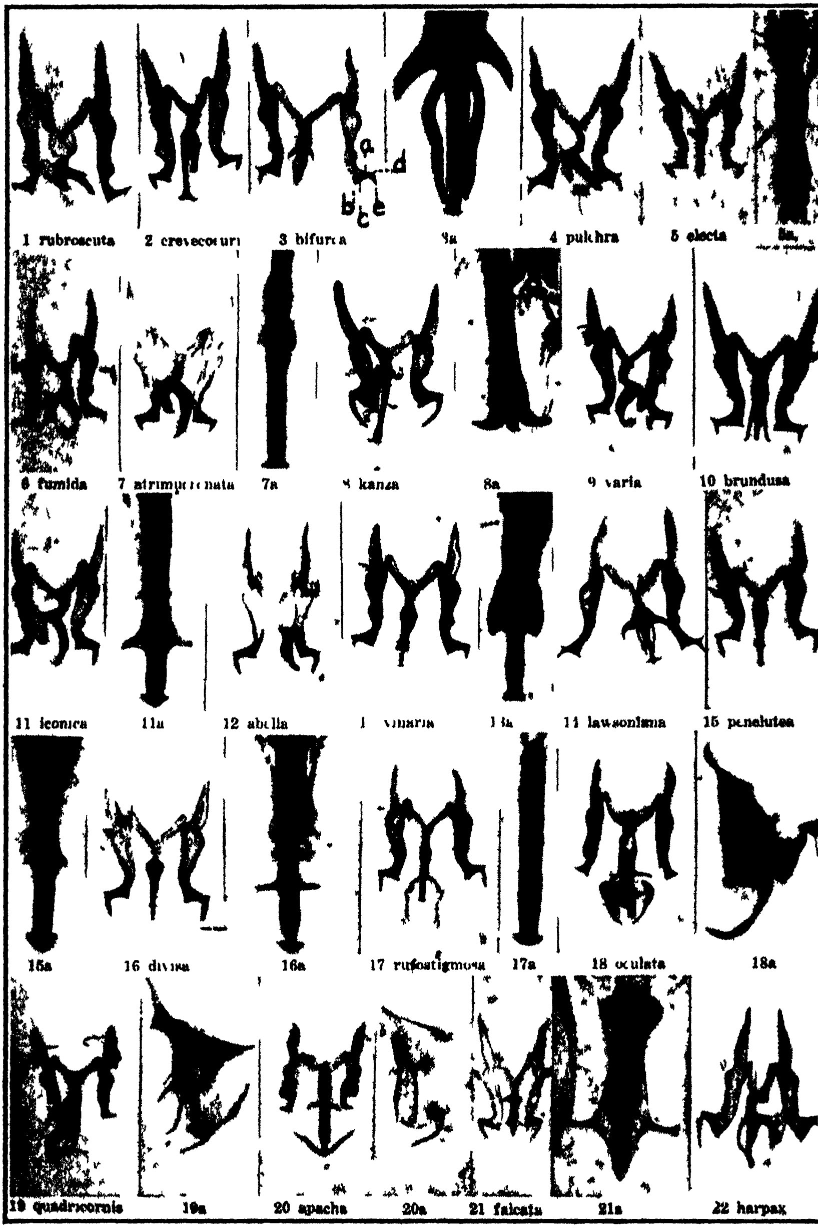
Styles with average foot; heel marked; base of foot straight; anterior point about a right angle; posterior point quite slender, sides converging, about one-half length of foot. Oedagus rather stout, curved dorsally with some teeth on dorsal margins; ends in a dorso-ventrally flattened and laterally widened tip. Two processes arise slightly before base, enlarge near their middle and end near apical fourth of shaft in even lateral curves.

Holotype, male, Johnson Co., Ill., March 30, 1929; P. W. Oman.

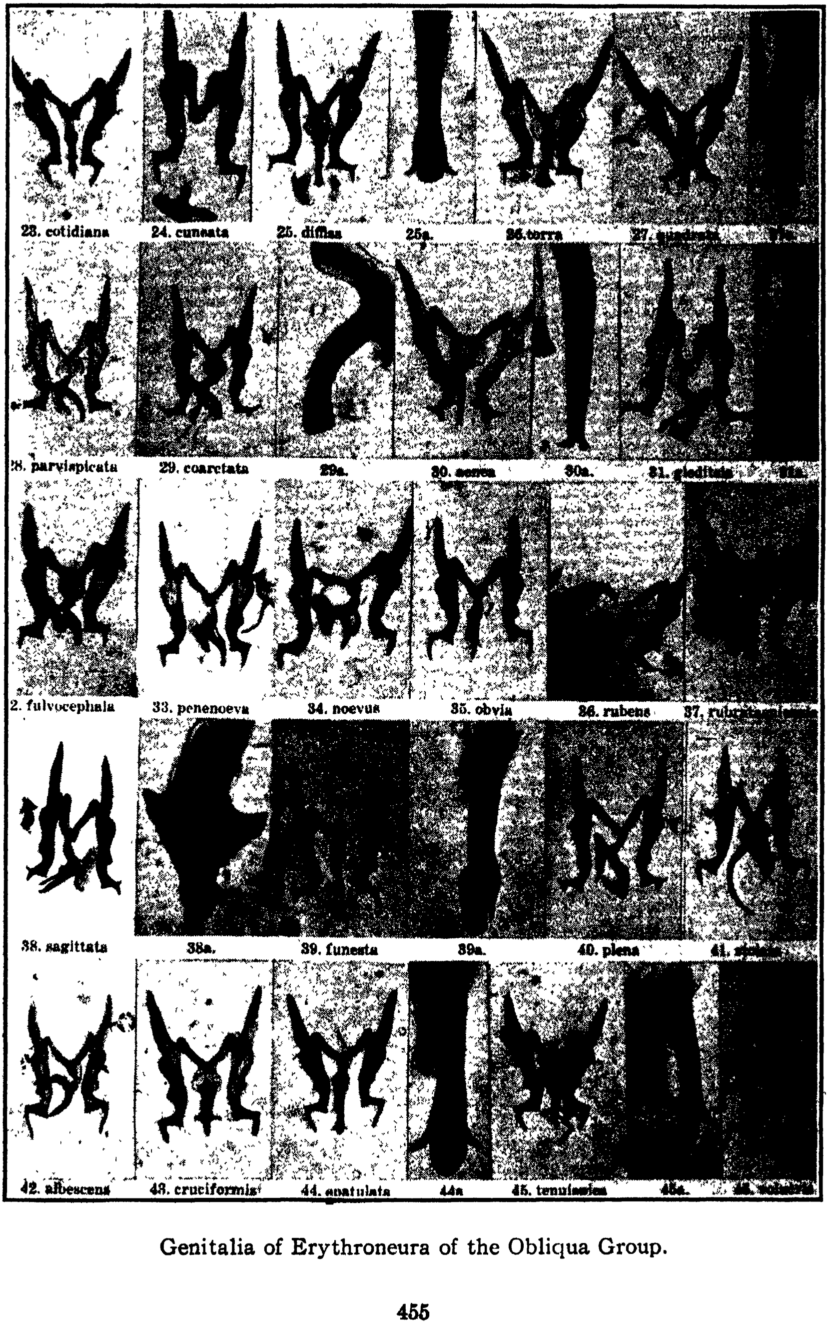
Allotype, female, Johnson Co., Ill., March 30, 1929; R. H. Beamer.

Paratypes, 21 males, Johnson Co., Ill., 1929, R. H. Beamer and P. W. Oman; 1 male, Anderson Co., Kans., P. W. Oman.

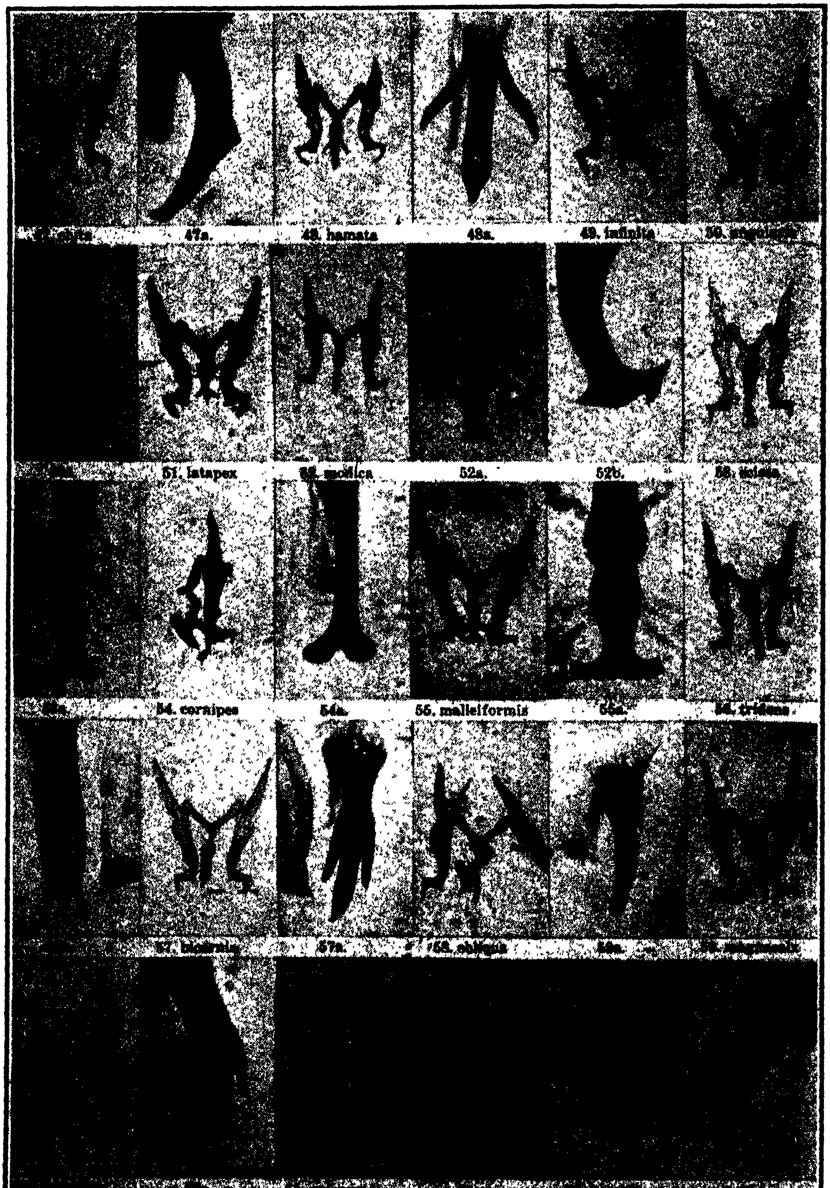
This species is close to *E. obliqua* (Say) in male genitalia but differs from that species in shape of oedagus and in having much larger and longer processes. It may be separated from that species externally by having hind tibia with one row of black spines.



Genitalia of Erythroneura of the Obliqua Group



Genitalia of Erythroneura of the Obliqua Group.



Genitalia of Erythroneura of the Obliqua Group.

THE LEAF-MINERS OF AQUILEGIA, WITH A DESCRIPTION OF A NEW SPECIES.

S. W. Frost,
Pennsylvania State College.

The cultivated columbine, *Aquilegia vulgaris* and the wild *Aquilegia canadensis* of North America are extensively mined by several species of Diptera. No Lepidoptera, Coleoptera or Hymenoptera are known to mine the leaves of these plants. No doubt the thinness of their leaves are uninviting to the miners of these orders, which usually prefer the leaves of trees or herbaceous plants. *Phytomyza aquilegiae* Hardy and *P. minuscula* Gour., are well known miners of Aquilegia. *P. aquilegiæ* Hardy probably does not occur in North America. *P. minuscula* Gour., is abundant throughout North America and produces the characteristic tortuous linear mines present wherever Aquilegia grows. It has been confused in American literature with *P. aquilegiæ* Hardy.*

Other Diptera namely; *Scaptomyza graminum* Fall., *Phytomyza* geniculata Macq., *P. obscurella* Fall., and *P. nigra* Meig., were recorded as miners by Brischke in 1880, but have not subsequently been reared by later specialists of leaf-miners. It is probable that *S. graminum* was reared from decaying leaves and that the species of Phytomyza were incorrectly determined, being the well known European *minuscula* or *aquilegiæ*.

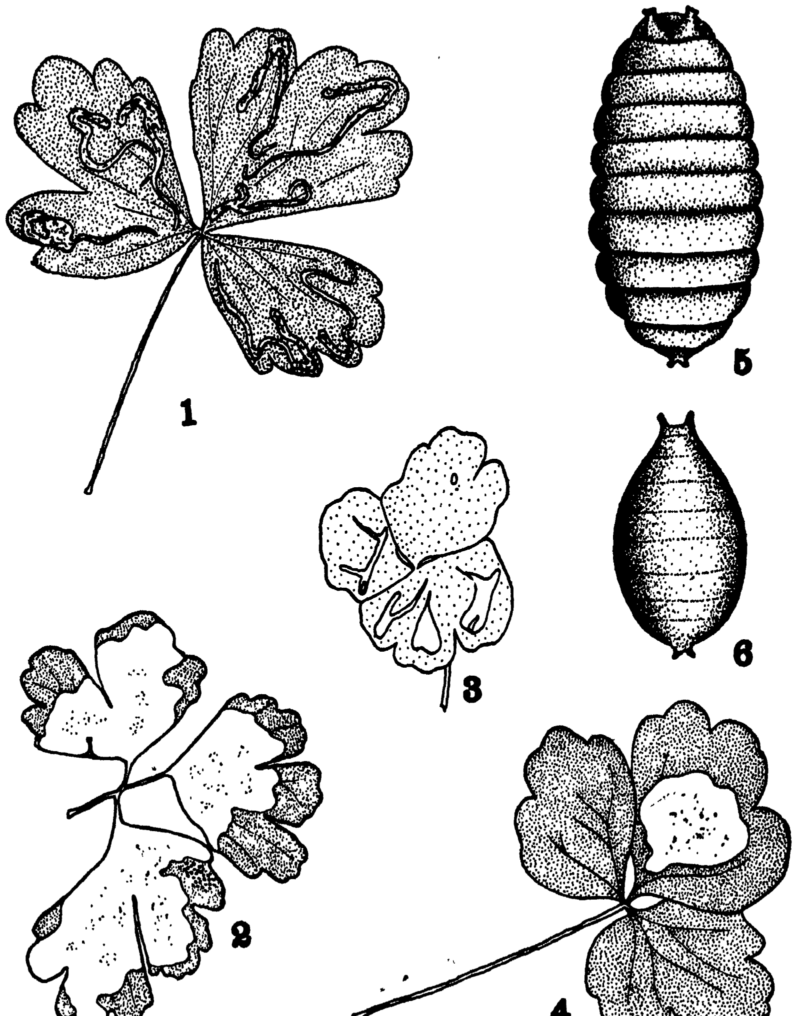
Phytomyza minuscula Gour.

Phytomyza minuscula Gour. (—*ancholiæ* R—D 1851, *aquilegiæ* R—D 1851 and *aquilegiæ* of American authors). Kaltenbach 1872, placed *albiceps* Meig., in synonymy but this species was subsequently removed by Becker-Bezzi, 1905.

Dr. Martin Hering examined specimens of the so-called *P. aquilegiæ* of American authors, reared and sent to him by the writer, and determined them as *minuscula* Gour.

In North America the species was first recorded from Connecticut by Dr. W. E. Britton under the name *aquilegiæ* Hardy. The species has been recorded under the same name by Coquillett 1898, Aldrich 1905, Melander 1913 and Frost 1928.

*This confusion was first pointed out by J. C. H. de Meijere, Tijdschr. v. Entom. 69: 274–275, 1926.



LEAF MINES AND PUPÆ OF PHYTOMYZA.

Fig. 1. Linear mines of *Phytomyza minuscula* Gour. on *Aquilegia vulgaris*.

Fig. 2. Blotch mines of *Phytomyza aquilegiana* n. sp. on *Aquilegia vulgaris*.

Fig. 3. Linear mines of *Phytomyza minuscula* Gour. (*ancholiæ* R. D.) redrawn from Goureau, 1851.

Fig. 4. Blotch mine of *Phytomyza aquilegiæ* Hardy on *Aquilegia vulgaris*, drawn from a specimen from Dr. Martin Hering, Germany.

Fig. 5. Puparium of *Phytomyza aquilegiana* n. sp.

Fig. 6. Puparium of *Phytomyza minuscula* Gour.

In Europe the species has been recorded as a miner of Thalictrum as well as Aquilegia. The writer has occasionally seen linear mines resembling those of *minuscula* on Thalictrum in Pennsylvania but has never reared the species. In North America the linear mines produced by this species on Aquilegia are at times so numerous that every leaf on a plant may be inhabited. In spite of their abundance the plant seldom seems to suffer injury. The habits of the species have been amply discussed by E. N. Cory, Jl. Econ. 9, 1916.

Phytomyza aquilegiæ Hardy.

The type of this species has apparently been lost.* Hardy's original description is brief, however, it suffices to separate *aqilegiæ* from *minuscula* with which it has been confused in American literature. Fortunately the two species are not closely related. *Minuscula* is a small shiny black species with small shiny seed-like or foot-ball shaped puparia. *Aquilegiæ* and *aquilegiana* are larger species more cinerous in color with larger dull colored puparia. Hardy, states that *aquilegiæ* make blotch mines also "Fronte flava." *Minuscula* makes linear mines and the front is fuscous.

Hendel 1918 places *nigra* Curtis in synonymy but subsequently removes it. Apparently *aquilegiæ* Hardy does not occur in North America.

Phytomyza aquilegiana n. sp.

This species runs close to the European *P. aquilegiæ* Hardy but makes blotch mines of a different type. It has been compared with a specimen determined by Dr. Martin Hering as *P. aquilegiæ* Hardy and differs in the following respects; front as wide or slightly wider than either eye, 4 fronto orbitals all about the same length, cheeks less than one-third eye height, acrostichals reaching almost to 4th pair of dorsocentrals.

Description.—A medium size species, 2½ to 3 mm. Front face and cheeks yellow; antennal grooves darkened, palpi and setæ brown or black, proboscis and setæ yellow; orbits concolorous with front, darkened on upper outer angles; ocellar triangle subshining dark brown

*Dr. Martin Hering writes, "I did not see the type of this species. . . . I cannot say where the types of Hardy have been placed." J. W. Edwards, British Museum, C. G. Lamb, Cambridge Museum, and J. M. Aldrich, U. S. National Museum, state that they have no idea where the type might be located.

and continuous with occiput which is same color; cheeks less than one-third eye height only slightly narrowed in front; yellow of cheeks extending back of eye but interrupted at vertex by the dark color of the occiput; front as wide or slightly wider than either eye, not at all produced at the insertion of the antennæ, sides parallel; four pairs of fronto-orbital bristles, all approximately the same length, a sparce row of small setæ on orbits adjacent to the eye margin, forward projecting and reaching from the upper to slightly below the lower pair of fronto-orbitals, a row of small setæ on the outer hind margin of the head continuing down the hind margin of the cheek, broken above into two or three rows and numerous below, back of mouth; a single pair of weak oral vibrissæ scarcely stronger than the accompanying setæ along the lower margin of the cheeks; antennæ entirely black, third segment about as broad as long, rounded at the tip and covered with brown pubescence, arista twice as long as third antennal segment, microscopically but distinctly plumose, slightly thickened on basal third. Mesonotum and scutellum subshiny brown lightly dusted, 4 pairs of dorsocentral bristles, the first and second pairs slightly weaker, five or six irregular rows of acrostichals reaching to or almost to the fourth pair of dorsocentrals, numerous small setæ outside the acrostichals, 4 scutellar bristles of equal size; sides of thorax cinerous, pleural sutures and base of wings narrowly yellow; 1 presutural, 2 notopleurals, 2 intraalars, 1 mesopleural, 1 sternopleural, accompanied by two or three smaller setæ, and 1 propleural bristle. Abdomen uniformily dark brown; legs brown, tibiæ and tarsæ paler Wings hyaline, faintly infumed, veins 2 and 3 diverging slightly at tips, vein 4 nearly straight, or slightly bending near its middle, vein 5 curving gently into the wing margin, 2nd, 3rd and 4th sections of costa as 3–1–1½, anterior cross vein 1½ times its length from the division of veins 2 and 3. Halteres pale yellow, calypteres and fringe pale.

Holotype ♂ Arendtsville, Pa. May 3, 1928, reared as a leaf-miner on *Aquilegia vulgaris*. 21 paratypes from Arendtsville and Ithaca, N. Y., May, July and September. The species runs very close to *aquilegiæ* Hardy.

Phytomyza plumiseta Frost, was recorded as a miner of Thalictrum and Aquilegia (Cornell Mem. 7p. 1924). but at that time it was confused with *Aquilegiara*. *P. plumiseta* dees not mine Aquilegia.

THE BEHAVIOR OF HIBERNATING POLISTES WASPS.

PHIL RAU,
Kirkwood, Missouri.

We are told in the text-books that in temperate regions *Polistes* hibernate as adults. The story goes that at the close of summer the queens and the males are born, and with the approach of cold all but the fertilized females succumb and that these queens hide in nooks and crannies during the winter and come forth in the following spring, when each one builds a nest independently. In a general way this is correct for *Polistes* as a genus, but when one takes the species separately and studies their hibernation in relation to their dissemination, each will be found to have unique details of its own to tell, and mayhap the story of each species will show sufficient variety to throw some light upon the relationships of the members of this genus. I make only a meagre offering, for I can throw light on the habits of only one species of *Polistes*, *P. annularis*, and give some incomplete notes on a few other species, which, however, show certain tendencies.

My interest was first attracted to this line of observation by finding thousands of these wasps hibernating in clusters among the crevices in the rocks at Cliff Cave on April 7, 1915.* I returned there later, at the beginning of the nesting season, fully expecting to find many paper nests of this species among the overhanging rocks, and was disappointed to find upon examination that not one of the many queens had built a nest in the region where they had hibernated. Since then, almost every year a pilgrimage has been made to the point, and each spring I have found *P. annularis*, and that species only, hibernating in the same way among the same crevices, and each summer the rocks have been examined for nests and each autumn after the falling of the leaves, a survey of the trees on top of the bluff has been made for the evidences of their nests, but no trace of their presence has ever been found. Hence it

*Wasp Studies Afield, 1918, p. 283.

has seemed logical to decide that these *P. annularis* undoubtedly had travelled to these bluffs from a distance, and the evidence derived from my later work substantiates this idea beautifully.

The limestone bluffs, fifty to a hundred feet high, are on the west bank of the Mississippi River, twenty miles south of St. Louis. The river at this point is about a mile or more wide; the east or Illinois shore is flat and often flooded, and about five miles inland is another series of limestone bluffs. The wasps nest among the vegetation in these lowlands during the summer and go to the western shore in the fall where they hibernate among the crevices of the rocky bluffs.

I have already described the nests of *P. annularis* made at the slough at Chesley Island.* That point is also on the west shore of the Mississippi and twelve miles below Cliff Cave. The slough itself is the channel separating the island from the mainland when the river is high, but goes dry and is partly overgrown with willows and swamp vegetation when the river is low. The area thereabout is flat, river bottom, which runs back to an abrupt hill about one-half mile west. On the top of this particular hill, four years' observations have never revealed a single nest of *P. annularis*, but *P. pallipes* always abound there. At the end of September and in the early half of October, however, hundreds of *P. annularis* come every year to the various clubhouses at the top and at the foot of this hill to hibernate. Often on warm days one sees hundreds coming out for an airing in the sunshine and later going into the cracks in the shanties. They usually occur in greatest abundance where the protection from the cold wind is the best, but I have never yet been able to find any of them hibernating near their nest. For instance, on February 26, 1921, in a spell of warm and bright weather, thousands of *P. annularis* were flying about and resting in the sunshine in a plowed field at the foot of the hill near the club house. Here they would fly awhile in an aimless languid manner, and then rest; often they could be picked up with the forceps. Here in this area, where none had built a nest in four years at least, they were abundant, while over near the island, where they had nested, not one hibernating *P. annularis* could be found on the wing in the sunshine, under bark or in the house boats, in the thorough search that

*Ecology, *10:* 191–200, 1929.

ensued that day. As it grew colder about 2:30 that afternoon, hundreds were seen crowding into crevices about the buildings. This evidence gives strong indication that the *P. annularis* population in this region leave their nesting places in the trees in the lowlands in the autumn and seek winter shelter about the foothills, finding it about the abandoned clubhouses, and rocky bluffs.

The following data give additional evidence that *Polistes* hibernate in some favorable place which is usually some distance from the site where they build. On April 23, 1920, a thorough search was made of nine club buildings (harboring nests of *P. pallipes* for four years) for *pallipes* queens which were about to build, hoping that I might be able to observe the process at its very beginning. But in only one shed were any of this species found. On two old nests of *P. pallipes*, near together, I found fifteen queens of Polistes, only three of which were *pallipes*, two *annularis* and ten *variatus*. Thus *P. variatus* predominated, although for three years no nest of *P. variatus* had been found hereabouts. This shows at least that, like *P. annularis*, *P. variatus* come together and seek shelter for hibernation at a point some distance from there old home site. When I approached, several of them walked away and out through a crack in the shed wall; several were picked up with the forceps and these proved to be queens. When I returned that evening one queen *P. annularis* was on a *pallipes* nest, and five queens of *variatus* on another, but when I again visited the shed, on May 28, I found no building activities had been undertaken here by *P. variatus* or *P. annularis*. Although hibernating *pallipes* were not seen hereabouts until the three were observed on April 23, on May 28 I counted thirty-one nests of that species. This indicates *P. pallipes* hibernate elsewhere and return to the home of their mothers to build.

On April 2, no *P. annularis* were in the field of corn-stuble and among the old buildings where on the previous visit had been thousands, only a few dozens of *P. annularis* were to be found; these were seen only late in the afternoon, and they moved with an air of indecision or restlessness, that probably meant site-hunting and approaching home-building. My curiosity awakened, I at once walked the half-mile to the island. The discoveries were ample reward for the pains. Please remember that on February 26 the same trip had been made and that not

one *P. annularis* could be seen there. Now, as I neared the region I found along the way more and more of the *annularis* on the wing, flying among the vegetation. As I reached the pond near the stream, I found several of them coming to the water's edge to drink. In the corners of the houseboat at the river's edge, more of them were at rest, which took to the wing at my approach; they were very alert and readily attempted to sting. The lethargic condition previously noted wherein I could easily pick them up, was not in evidence today. Very often when I broke a piece of loose bark from a tree I would find underneath it an *annularis* wasp, no doubt enjoying temporary shelter. But most important of all, when I arrived at their old haunts and came to the dozen or so of their old nests in various tree-tops, I found from eight to fifteen queens on each. They were not scattered about over the nests, but on each nest the wasps remained huddled together in a group at one edge. They frequently licked one another, and often the mouth-parts met as though they might be getting some nourishment from their comrades.

Evidently, then, I had had the good fortune to catch them at their exodus—in fact, just as they were entering their promised land, which however, sadly lacked milk and honey. The fortunate observations of that one day show decidedly that they had left the quarters of their temporary winter abode and were migrating, moving as an unorganized mass of great numbers would, back to their summer habitat—in reality, their old home. Their migration was very similar to that more familiar phenomenon, the migration of birds. Finding that they had gone, in significant numbers, back to the old nests of the species, I at once jumped to the conclusion that those which rested on the nests were the queens which had lived there the year before; that this occasion was to them a true home-coming. It seems not at all impossible that queen wasps which spend the last weeks of autumn on the nests should remember and return to these nests after a winter's absence, and there again become gregarious, lick or caress one another, or perhaps renew acquaintances, or revive the old feeling of family oneness—however you may wish to express it—and possibly strengthen the bond by the mutual aid of giving to each other some refreshment, however slight it may be, at this serious time of need.

The evidence bears me out in the theory that this home-coming affair is a link between the end of the hibernation period and the beginning of the new nests, and the dissemination of queens really occurs from the point of their old home instead of from the place of hibernation. That is probably how we can account for nests of *P. pallipes* being built in certain buildings year after year, while other places which according to our ideas are just as desirable never have a *Polistes* nest. This method of home-coming before dessemination undoubtedly accounts for the growth and dissemination of the *P. annularis* population on Chesley Island as recorded by me in Ecology (**10**:191, 1929).

So far my observations point to the conclusion that the habits of *P. pallipes* are similar in these matters. To be sure, I have not yet been able to discover where the *pallipes* population of this vicinity hibernates, but I know that the resident wasps "go away for the winter" somewhere, for on February 26, as I have already stated, not one was to be found thereabouts, when the *annularis* were so plentiful. On the later date, April 2, when the latter species went back to their summer home near the shore, these *pallipes* did likewise by coming home to the club-houses, and more than twenty were counted about the one building which contained their last year's nests and by April 18 fifty queens had nests about the buildings.

A significant remark by Wm. T. Davis* shows that in *P. pallipes* this love for the old home site is not restricted to the Missouri wasps. He finds in a cemetery in New York, under a fallen grave stone, nests of this species built during succeeding seasons for four years. This causes him to say, "Just as a phoebe returns each season and builds its nest in the old site, so succeeding generations of *Polistes* had done, and built their nest under the sheltering grave stone." Another significant observation by Davis in late autumn is that long after the nest had been removed and even the sheltering stone had been taken away, the females were still attracted to its one time site and the place of their birth. Even up to November 2, he found them there, and it is natural to surmise that, if they survived the winter, they would build near by next spring.

*Proceedings Staten Island Institute of Arts and Sciences, Vol. 2: 137, 1924.

Polistes rubiginosis was likewise not to be found in this locality on that warm, sunny day in February, but on April 2 they were conspicuous around their old homestead, which was between two walls. Thirty or more of these were seen coming to the knot-hole and otherwise behaving in a way identical with their conduct at the close of the previous summer.* They would crowd close together and lick one another, and when a *P. rubiginosis* returned from the field (if not from a longer journey) they would fight for the opportunity of touching its mouth with their own. This behavior was so similar to their conduct when they were watched in the preceding autumn that the observer could hardly realize that a winter had passed between. Whether these *P. rubiginosis* had migrated elsewhere for the winter, or whether they had hibernated in the space between the two walls, I can not tell.

To conclude then, there does seem to be some analogy between the home-coming of birds after migrating to escape the severe winter, and the home-coming of *Polistes* after hibernating in sheltered spots for the same reason. Both migrations have the same end in view; the birds travel long distances, and the wasps short ones, both to return to the home region in due season. There is this difference however: the long-lived bird covers greater time and space and retains memory images longer, and the wasp whose life is short covers shorter distances, and refreshes its memory of the home site by frequent visits during the warm days of autumn and early spring.

*See article in Ent. News *40:* 7–13, 1929, entitled "At the End of the Season with *Polistes rubiginosis*."

OBSERVATIONS ON THE ANOPHELINI (CULICIDÆ) OF BAHIA, BRAZIL.*

RAYMOND C. SHANNON AND NELSON C. DAVIS
Yellow Fever Laboratory, Bahia, Brazil.

The species of Anophelines treated herein were collected during the course of current investigations, the object of which is to test the ability of the wild species of Culicidæ to transmit the yellow fever virus.

The known Anophelines of the State of Bahia have been listed twice. The species which have been collected to date by the writers are given in the following table which also includes the two previous lists.

Borroul, 1904	Peryassú, 1921	Present List
A. (N.) argyritarsis (as *Cellia argyritarsis*)	*A. (N.) argyritarsis* (as *Cellia argyritarsis*)	*A. (N.) argyritarsis*
A. (N.) tarsimaculatus (as *Cellia albipes*)	*A. (N.) tarsimaculatus* (as *Cellia albimana*)	*A. (N.) tarsimaculatus*
		A. (N.) bachmanni
	A. (N.) albitarsis (as *Cellia brasilensis*)	*A. (N.) albitarsis* and var. *brasilensis*
	A. (N.) lutzii (as *Myzorhyuchella lutzii*)	
	A. (K.) cruzii (as *A. luztii*)	*A. (K.) cruzii*
A. (Arr.) mediopunctatus (as *Cyclolepidopteron medio-punctatum*)	*A. (Arr.) mediopunctatus* (as *Cyclolepidopteron medio-punctatum*)	*A. (Arr.) mediopunctatus*
		A. (Arr.) intermedius
	A. peryassui (as *Manguinhosia lutzii*)	*A. peryassui*
		A. minor
	Stethomyia nimba	*Stethomyia nimba*
	Chagasia fajardoi	

A total of twelve species and one variety is therefore known to date for the State. Species listed by Bourroul and the present writers were collected within a radius of a few miles of the capital of Bahia, (Sao Salvador). The inclusion of

*The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Division of the Rockefeller Foundation.

"*Myzorhynchella*" *lutzii* and *Chagasia fajardoi* indicates that the species listed by Peryassù came from a greater radius, probably from the interior, since the two species mentioned prefer upland regions, and are probably not to be found in the coastal lowlands in the vicinity of Sao Salvador.

Three of the species at hand, *Stethomyia nimba*, *Anopheles peryassui*, and *A. minor* are of unusual interest and a detailed account of them is given.

TERMINOLOGY.

As a result of the various attempts which have been made in recent years to homologize the structures of the larval and adult stages of the Culicidæ, a number of views have been expressed which are at more or less variance with earlier interpretations. Consequently a number of changes have been recommended which would radically affect the old morphologial nomenclature. However, as the opinion varies somewhat regarding the homologies and owing to the multiplicity, and sometimes to the cumbersomeness, of the terms which have been proposed, it may be well, at least for the time being, to retain, so far as possible, the earlier terminology for taxonomical work.

There are however a number of changes which, owing to the absolute inaccuracies of the older views, must be adopted. A list of the terms in question, are here discussed.

Sclerotized Structures.—Ferris and Chamberlain (1928), Snodgrass (1929), and Campbell (*vide* Snodgrass) have shown that the hardness of the so-called chitinized areas of insects is not due to a proportionate amount of deposited chitin, but to indeterminate substances intimately associated with the chitin, which were present with it when the hardening process begins. Further (*vide* Ferris and Chamberlain) that the magenta and acid fuchsin stains are specific, not for the chitin, but for the other substances (possibly of a protein nature) associated with it, i. e., that which causes the hardening or sclerotization. In the preparation of specimens for staining, too prolonged treatment with alkalis or too intense heat will remove or alter the substances in such a way that the stains are not effective.

The ninth abdominal segment of the larva.—Christophers (1922) calls attention to the fact that the mosquito larva possesses ten abdominal segments, rather than nine; that while the apparent eighth segment is actually this structure, the greater part of the spiracular apparatus must be assigned to the tergite of a hitherto unrecognized ninth abdominal

segment. The toothed structure in *Anopheles* which has been termed the comb, Christophers considers to be homologous with the pecten which is borne on the siphon in the Culicine larvæ, rather than to the eighth abdominal comb of the same; he suggests that this structure, which is likewise borne on the ninth segment, be called the pecten of *Anopheles* larvæ. The pecten plates are joined by a slender sclerotized arched bar which lies below the respiratory apparatus. The anal, or so-called ninth abdominal segment, becomes the tenth.

Thoracic sclerites.—The terms used by Dyar (1928) are employed here with some slight modifications.

Merocoxa (Crampton, 1925) is substituted for the "lateral metasternal sclerite" of Dyar's publication.

Crampton has shown that the *sternopleurite* which superficially appears as a single sclerite in the Culicidæ, is in reality composed of two structures, the posterior anepisternum and the sternopleurite, the two having fused together. The former structure bears the prealar setæ and for this reason, the sclerite may be called the prealar sclerite, in conformity with Edward's system, (1921). In some species of Culicidæ, a more or less obvious membranous area still separates the two. This is usually the case in the Anophelini, while in at least some species of *Uranotaenia*, a straight line of demarcation (best seen in caustic-treated specimens) indicates the line of fusion. In *Stethomyia nimba* the prealar sclerite is membranous (save for the internal sclerotized spur, present in all Culicidæ, even when the prealar sclerite is sclerotized) and without setæ.

The usual location and number of pleural setæ present in the Anophelini are as follows: three to six propleurals; about ten on the prothoracic lobes; pronotum usually bare; three to five spiraculars; postspiraculars absent; paratergite bare; about seven prealars; one to three upper sternopleurals; about three lower sternopleurals; and eight to ten upper mesepimerals. Some of the marked exceptions to the above arrangement are: *Chagasia* with about ten pronotals and the paratergite clothed with scales, other setæ also more numerous; *Stethomyia* with three to five setæ on the prothoracic lobes, one propleural seta; no spiraculars, no prealars; and two upper mesepimerals. *Bironella* and some species of *Myzomyia* likewise lack the spiraculars (Edwards, 1924). *Anopheles mattagrossensis*, a tropical American species (specimen at hand from Rio Catatumba, Venezuela) has four well developed setæ, widely separated from the upper series, and centrally situated on the mesepimeron.

THE TERMINALIA OF THE MALE ANOPHELINI.

Terminalia (Freeborn, 1924) is an all inclusive term for the anal and genital structures and the abdominal segments intimately associated with them. In the male Culicidæ, owing to the fact that all of the parts caudad of the seventh segment undergo a torsion of 180°, whereby the normally ventral surface becomes secondarily dorsal, the term *terminalia* is applicable to all structures caudad of the seventh segment; and,

inasmuch as the parts are directed outwardly and in the same plane with the abdomen as a whole, the term is preferable to that of hypopygium (signifying "below the rump") and also to that of genitalia, which strictly speaking applies only to the sexual organs.

Dorsal and ventral aspects of the terminalia.—After torsion, there is a reversal of the dorsal and ventral aspects of the terminalia, but some authors call the secondarily ventral aspect, the ventral; while others consider it the dorsal, as if in its original position. The latter view is preferable, especially as the terminalia, as a rule, are mounted to show the anal segment uppermost. Likewise most of the figures published have this aspect uppermost. If necessary to avoid confusion, the aspects may be termed the sternal and tergal aspects respectively.

Classification of the terminalia.—The structures are divided (Edwards, 1920) into four groups.

1. The ninth segment. (The eighth is without significance in the Anophelini.)
2. The appendages (forceps) of the ninth segment.
3. The tenth or anal segment.
4. The phallosome (or sclerotized parts of the genitalia).

1. *The ninth segment.*—In the Anophelini both sternite and tergite are present, the sclerotized portions usually forming a narrow ribbon. The sclerotic areas vary somewhat in the different species and both sternite and tergite at times may be almost entirely membranous. Free lobe-like processes may be developed, but well differentiated setæ are lacking.

2. *The forceps, or appendages of the ninth segment.*—A pair are present, each consisting of three primary structures: side-piece, style, and appendicle (appendage of the style). A fourth structure, the claspette (interbasal fold) lies between the bases of the side pieces and is attached to them.

(a) *Side-piece*—(Basistyle, etc.). A comparatively simple structure in the Anophelini, consisting principally of a hollow sclerotized tube. There may be more or less well defined sclerotic lacunæ (non-sclerotized areas) on the inner surface, best shown in freshly stained specimens. The *apodeme* (Edwards) is in an internal prolongation of the base of the side-piece which shows as a strongly sclerotized curved arm. In addition the side-piece possesses from two to five spines, and one or more lobes.

(b) *Style or clasper.*—A long sclerotized rod occurring at the distal end of the side-piece.

(c) *Appendage of the style or clasper.*—In the Anophelini this is a small spine-like structure situated at the apex of the style, but in some of the other Culicidæ it assumes various shapes and sometimes position. It may be advantageous to shorten this expression to "appendicle" (appendicula).

(d) *Claspette.*—(Interbasal fold or lobes, harpagonal fold). Largely a membranous structure consisting of one or more lobes bearing several pairs of spines, some of which may be modified. Lies ventrad to the

phallosome between the bases of the side-piece to which its lateral ends are attached.

(e) *Parabasal lobe.*—The parabasal spines, located on the inner, basal portion of the side-pieces are usually situated on separate, well-defined tubercles or lobes, termed the parabasal lobes. These are considered to be portions of the claspette that have become attached to the side-pieces.

3. The ***tenth*** or ***anal segment*** (of authors) (= proctiger of Freeborn, 1924). In Anophelini this consists principally of a membranous cone-like structure, but more or less strongly sclerotized lateral arms (cerci Christophers, paraprocts Freeborn, 10th sternites Edwards) may be present. These in turn occasionally have (e.g. in *Stethomyia*) a spur-like protuberance. The epiprocts (Freeborn 1924) or tenth tergites (Edwards 1920) are said by Freeborn to be present in *Anopheles* "in the form of diffuse chitinization fusing with that of the paraprocts, which is so faint as to be indistinguishable, yet sufficiently heavy to cause the proctiger (anal lobe) to remain visible in potash mounts, which is seldom noted with the membranous parts of this organ in other genera."

4. ***Phallosome*** (Christophers, 1922) (*Aedoeagus, mesosome*).—"The phallosome * * * lies sheathed in the chitinizations of the penis cavity * * * springing from the ventral body wall at the base of the tenth segment * * * In *Anopheles* it forms the narrow rod-like organ characteristic of the genus," and possesses an apical opening (Christophers). In addition, it may be noted that the lateral sclerotized arms of the phallosome in the Anophelini usually diverge basally, forming thereby an inverted "V." One of the principal differences between *Stethomyia* and the other Anophelini occurs in the form of the phallosome of which a detailed description is given under this genus.

The dorso-lateral plates (Christophers).—A pair present, one at the dorso-lateral base of each lateral arm of the phallosome.

The *junctura* (Christophers) lies between the dorso-lateral plate and the apodeme of the side-piece.

THE FEMALE TERMINALIA.

For a description of the female terminalia see Christophers, 1923 and Davis, 1925.

TECHNIQUE

It has been found advantageous to use several more or less recently proposed modifications in the method of treating insects, or their parts, for microscopic study. The following method has given considerable satisfaction.

The entire specimen, or a portion, is boiled in a ten per cent solution of potassium hydroxide for two or three minutes and immediately transferred to a solution of acetic-alcohol, consisting of eighty parts of fifty per cent alcohol and twenty parts of glacial acetic acid. The specimens may be left indefinitely in this solution or removed after a

minute and placed on a slide in one or several drops of Gater's mounting medium; the specimen is then ready for examination, and, by placing a cover slip on the specimen, a more or less permanent mount is obtained. The mountant proposed by Gater (1929) is a modification of the Berlese medium and was devised for the purpose of mounting Anopheline larvæ directly from water and for preserving them for future study. Its use has been found extremely convenient in studying the terminalia of Anophelines. In addition to the rapidity with which the specimen may be prepared the medium possesses sufficient consistency so that the specimen may be placed on the slide in any position without subsequent undue rolling. Also, the medium resists drying for a considerable time, but even after drying fresh mountant or acetic alcohol may be added to that already on the slide. After examination, the specimen may be returned to the acetic alcohol solution or made into a permanent mount. Although sufficient time has not elapsed in order to note the rapidity or degree of fading, it is believed that it will not be so rapid or as complete as with specimens mounted in Euparol.

Occasionally, staining will help to differentiate characters. When needed, specimens may be placed directly from the acetic alcohol into a weak solution of acid fuchsin (saure-fuchsin 0.5 grams; 10 per cent hydrochloric acid, 25 cc.; distilled water, 300 cc.) for an hour, washed briefly in 95 per cent alcohol, and then be placed in Gater's medium. The stain gradually fades in the mounting medium but remains sufficiently strong for hours. After the stain fades, the specimen may be removed from the mountant, washed a few minutes in acetic alcohol and then restained.

For staining methods see Ferris and Chamberlain, 1928, and Ferris, 1929. Another paper (Imms, 1929) has just come to hand which contains the original Berlese formula and also the formula of the De Faure fluid which is somewhat of a similar nature. In addition, the paper discusses staining methods and other entomological technique.

DISCUSSION OF SPECIES

Genus **Stethomyia** Theobald.

Stethomyia Theobald, Journ. Trop. Med., 5: 181, 1902.

The genus *Stethomyia* was established by Theobald (1902) with *S. nimba* as the genotype, although the species was not described until the following year (Theobald, 1903). In 1918 Dyar reduced the genus to subgeneric rank, while Christophers (1924), Bonne and Bonne-Wepster (1925), and Root (1929) have regarded it as a complete synonym of *Anopheles*. As will be shown below, *S. nimba* possesses characters at such marked variance with the other members of Anophelini in the larval and adult (male and female) stages that it cannot be consistently treated as a member of the genus *Anopheles*.

Stethomyia nimba Theobald.

S. nimba, originally described from British Guiana, is now known to occur in Panama, the Guianas, and Brazil. However, it is only during the last ten years that breeding places of the larvæ have been found, but to date, no description of the larva has been given, and not until 1925 (Bonne and Bonne-Wepster) and 1928 (Dyar) has the male terminalia been described. In the descriptions of the terminalia, although certain characteristic features were noted, that given by these authors for the phallosome has been so incomplete as to leave its true nature unknown.

The larva was probably found for the first time in 1923, in a shaded rock-enclosed spring, on the Atlantic side of the Canal Zone (J. B. Shropshire). Bonne and Bonne-Wepster (1925) record finding larvæ in a permanent pool in Surinam. Chamberlain and Curry (1928) also record the occurrence of larvæ in the Canal Zone, in shaded pools associated with *A. eiseni*, *A. punctimacula*, and *Culex declarator*. The writers found small numbers of larvæ early this year (1929) on several occasions in a small spring-fed swamp (Pirajá, Fratelli Vita, a few miles distant from the city of Bahia). A little later (June) Dr. Jose Serafim, of the Saude Publica of Bahia, found larvæ in a small temporary pool in a locality (Pirajá, Barros Barreto) where the writers had collected mosquito larvæ on several previous occasions, and where up to this time its presence

had not been suspected. However, heavy rains had caused water to flow from temporary springs, and the water accumulating in a pool, largely shaded by trees, had created decidedly favorable breeding conditions. The temperature of the water was distinctly lower than in the unshaded pools. According to our local records it seems possible that the species is not only addicted to cool spring waters but breeds more abundantly in the cooler winter season. During the same month (June) the writers collected several hundred larvæ and a few pupæ from the last-mentioned source. Three species of *Corethrella*, one species of *Dixa*, and a few *Culex* larvæ were found associated with *S. nimba* in this locality, whereas in the Pirajá, Fratella Vita, locality, larvæ of *An. peryassui* and an undescribed species of *Uranotænia* were found along with the *nimba* larvæ, as well as one of the species of *Corethrella* and the *Dixa* species. The last-mentioned species of *Corethrella* is the only one of this group of spring-swamp-water-loving species that has been found to date in other types of breeding sources.

The adults have been very little in evidence in the vicinity of their larval sources. Only on one occasion has a female been seen to attempt to bite man but owing to its extreme shyness, it did not actually attack. Also, on three occasions, attempts were made to obtain adults by using a horse as bait, but only one specimen was thus captured. Two adult males were collected with an insect net in a small well-shaded, overhanging clay bank at a place apparently some distance from a breeding source.

After a little experience, it became very easy to distinguish the larvæ of *S. nimba* at sight, chiefly by its rather short (about six millimeters in length) but proportionately broad appearance and yellowish color.

Larvr: (Figure 1.) Antenna with a small two or three branched hair basad of the middle; the anterior clypeal hairs simple, rather stout, the median ones fairly long and well separated; the outer thoracic shoulder hair remarkably long, extending well beyond the anterior head margin; the anterior median thoracic hairs with about seven slender branches; the abdominal palmates represented by extremely inconspicuous, transparent structures with very long (over twice the length of the stalk) filamentous leaflets; the lateral hairs on segments four to seven sparsely plumose; the spiracular openings on the ninth segment widely separated; this segment also bearing a pair of long,

slender, segmented (as seen under high magnification) hairs which divide midway of their length into four branches. The basal, segmentedportion (see Figure 7) resembles the cerci found in stone-fly nymphs (Plecoptera) and in adult Mayflies. They are quite distinct from the lateral papillæ and their appended hairs, as these are likewise present, as well as from a hair borne on a membranous lobe ventrad of the papilla and a fourth hair attached to a heavily sclerotized tubercle, distad of the fossate hairs. The posterior flap is short and broad; each set of grappling hooks consisting of seven or eight hairs.

Pupa: (Figure 2.) Closely resembles the Anopheline type. The trumpets are rather small, with a sub-quadrate opening and the spines on the eighth segment are plumose. The "frontal sclerite" of the cephalo-thorax is undivided as in the other Anophelini.

Adult: Female. A small, slender mosquito with very long legs. Dark colored save for a patch of white scales between the eyes (the only white scales present in the species), and the thoracic markings, consisting of a slender median milky white line extending from the anterior to the posterior margin of the mesonotum and the pale lateral margins of the mesonotum. The erect head scales are slender and rod-like, usually with blunt tips.

Head: Antennæ of normal appearance, length 1.2 mm. Proboscis long, 1.8 mm., and slender with appressed scales and minute setæ; each labellum about three times as long as wide; palpus slender, slightly subequal to length of proboscis (1.7 mm.), clothed with appressed scales, and with a row of well defined setæ extending on the outside surface for the full length of the palpus, a group of long setæ present at the apex.

Thorax: (Figure 23) Prothoracic lobes with but three to five well scattered setæ; pronotum without setæ or scales; prespiracular sclerite bare; one propleural seta; three mid- and one upper-sterno pleural setæ; prealar sclerite membranous and without setæ; two upper mesepimeral setæ.

Legs: Very long and slender. Fore leg: 7.0 mm. (tibia 1.8 mm., basitarsis 1.7 mm.); mid legs: 7.5 mm. (tibia, 2.0 mm.; basitarsis, 2.0 mm.); hind leg: 9.0 mm. (tibia, 2.0 mm.; basitarsis, 2.4 mm.).

Abdomen: Dark colored, without scales, the basal sternites weakly sclerotized. The terminalia are essentially characteristic for the tribe, save that the ninth sternite is fairly well developed (see Figure 10), and the cerci are rather long and slender (4 by 1). Only scattered setæ are present on the cerci.

Wings: Scales entirely dark, narrow; length 3.3 mm.; width 0.8 mm. Halteres with appressed dark scales.

Male: Third palpal joint fused with the second. Claws essentially the same as in the other American Anophelini.

TERMINALIA: *Ninth Segment.*—Composed of both tergite and sternite, the two being weakly fused together laterally. The tergite is divided at its middle and has a pair of comparatively poorly developed lobe-like processes (Figure 8) which probably correspond to the more fully developed processes found in the species of the group *Anopheles* (subgenus *Anopheles*).

Anal Segment: Conical, largely membranous but with a pair of sclerotized sternites (paraprocts, Freeborn). Each of these has a ventrally directed spur, the tip of which is opposed to the modified spines of the claspette. (In Figure 8, the anal lobe with the adjoined anal segment is shown in a flattened condition).

Appendages of the ninth segment.—The side-piece is rather small and slender. It possesses a large saber-blade-like parabasal spine and a slender internal spine. In freshly stained specimens there may be seen a triangular-shaped basal lacuna the apex of which extends as a slender line to an apical lacuna. The style is somewhat longer than the side-piece and the length of the appendicle is shorter than the width of the style.

Claspette.—(Figures 12 and 13). Consists of a ventral membranous lobe which is low and has a slight inward convexity on its apical margin. In addition, there are three large tubercles, the ventral one (above the ventral lobe) bearing an elongated transparent spine which has a distinct subapical tooth; the median one bears a stout opaque spine and the dorsal lobe has a pair of closely applied modified spines. These last are broad and strongly convexed; in their natural position, they form a scoop-shaped hood overhanging the median and ventral spines. Between the ventral lobe and the dorso-lateral plates of the phallosome is a distinct subquadrate opening.

Phallosome (Figure 14). The base is composed of a broad thin plate (as shown when on edge) which is shaped like a shallow trough, the lateral margins being directed upwards. From its baso-ventral corners arise the lateral arms of the phallosome. Their distal portions twist freely when pressure is exerted on the cover slip, thereby indicating that they are apically unattached. Distad to the basal plate and dorsad to the lateral arms, is another thin plate, somewhat thimble-shaped in outline. This is definitely attached to the basal piece (as shown by the impossibility of removing it entire) although there is a definite line of demarcation at its base. The basal plate possibly corresponds to the ventral bridge found in other genera of Culicidæ, but should be termed the basosome pending its definite homology. The thimble-shaped plate possibly corresponds to the dorsal bridge of other Culicidæ but should be termed for the present, the dorsal plate. That this sclerite may be the true episome (as described by Christophers, 1922) from which the epimeres or leaflets are derived is indicated by the presence of a thin, transparent (in stained specimens), apical structure found on the phallosome of certain species of the *Anopheles* group, e. g. *A. punctipennis* Say (see Figures 9 and 9a). In the latter species, the leaflets are clearly appendages of the apical transparent structure.

Basad of the basosome is a pair of sclerites which probably correspond to the dorso-lateral plates of Christophers (p. 554). Each of these has a laterally adjoined sclerotized structure which is articulated to the apodeme of the side-piece. These in turn probably correspond to the junctura of Christophers. The dorso-lateral plate is sub-quadrate in a directly end-on-view of the terminalia, while the junctura and apodeme are similar in appearance to those of the subgenus *Anopheles*.

The above study of this species indicates it to be of a primitive archaic type, radically distinct from the other American Anophelini in a number of respects. However, certain other Anophelines, chiefly Old World species, share one or more of the peculiarities of *nimba*, and the following tabulation calls attention to these and to the species possessing them. The information regarding the Old World forms, has been obtained largely by letter from Dr. F. M. Root and the publications of Christophers (1924), Edwards (1924), Mackerras (1927) while that for the American species was obtained from Root (1926, July 1927, September 1927).

1. *Rudimentary palmate hairs.* *A.* (*An.*) *brevipalpis* Roper (North Borneo: Malay States); *A.* (*An*) *novumbrosus* Strickland (Malaya); *A.* (*An.*) *separatus* Leicester (Malaya); *A.* (*An.*) *atratipes* Skuse (Australia). In *A. novumbrosus* developed palmate hairs are present on two abdominal segments. All of the above species have been referred to the subgenus *Anopheles* and occur either in the Malayan region or in Australia. They differ from *S. nimba* in having leaflets on the phallosome and in the possession (in all?) of thoracic scales which are lacking in *nimba*.

2. *Phallosome without leaflets.* *A.* (*An.*) *plumbeus* Stephens (Europe); *A.* (*An.*) *barianensis* James (India); *A.* (*An.*) *barberi* Coquillett (Eastern United States); genus *Chagasia* (tropical America); subgenus *Nyssorhynchus* (with *argyritarsis* R. D. and *darlingi* Root as exceptions; however, these species have atypical leaflets) (America, chiefly tropical); subgenus *Kerteszia* (tropical America); *A.* (*An.*) "species", "Phallosome with fimbriated frill but no leaflets," *vide* Christophers (Malay); *A.* (*Myzomyia*, group *Myzomyia*) *multicolor* Camboulin (North Africa, Palestine); *A.* (*Myzomyia*, group *Cellia*) *pulcherrimus* Theobald (Mesopotamia, Turkestan, Northwest India).

According to the above species, the absence of leaflets is evidently sporadic, occurring in members of the tribe widely

separated taxonomically and geographically. However, the point at issue here is whether in *S. nimba* the episome remains in the primitive condition and the leaflets have never developed (and such is apparently the case) or whether they have been lost as in the other species. As mentioned under the description of the phallosome of *S. nimba*, a thin transparent structure is to be found at the apex of the phallosome of *An. punctipennis*, to which the leaflets are attached. This structure probably is a vestige of the episome. *A.* (*Nyssorhynchus*, *Myzorhynchella*) *parvus* (Chagas) may represent another intermediate step in the development of the episome. As just stated above, the species of the group *Nyssorhynchus* (subgenus *Nyssorhynchus*) do not possess leaflets except for the presence of atypical leaflets in *argyritarsis* and *darlingi*. The tip of the phallosome of *Myzorhynchella parvus*, according to Root (1927) "bears a pair of reflexed leaflets, not unlike those of *argyritarsis* or *darlingi*. But between these leaflets, there is a zone of chitinization which is continued apically to form a pointed hook-like structure. bent over towards the dorsal lobes at its tip." This "zone of chitinization" may represent a fairly large vestige of the episome, which eventually becomes more or less completely lost in the species belonging to the *Nyssorhynchus* group.

3. *One parabasal spine present.* All species of the subgenera *Nyssorhynchus* and *Kerteszia* (American); *A.* (*An.*) *stigmaticus* and *atratipes* Skuse (Australia); *A.* (*Christya*) *implexa* Theobald (Africa).

In these species the lateral arms of the phallosome are separated basally; moreover the species of *Kerteszia* and *Nyssorhynchus* bear two accessory spines on the side piece, while the other species possess phallosomic leaflets.

4. Head "scales" rod-like: *A.* (*An.*) *stigmaticus* Skuse (As *A. corethroides* Theobald, *vide* Christophers; synonomy *vide* Edwards): ? *A.* (*An.*) *atratipes* Skuse (no information is at hand regarding this character in *atratipes*, but it is provisionally referred here owing to its relationship to *stigmaticus*); *A. A. aitkenii* James (Orient).

5. *Spiracular setæ absent. Bironella gracilis* Theobald (Papua). "Also absent in some species of the subgenus *Myzomyia*" (*vide* Edwards, 1924).

6. *Characters believed to be strictly peculiar to Stethomyia.*

As far as is known, the following characters are not shared by any of the other species of Anophelini: Larva with widely separated spiracular openings on the ninth tergite; the ninth tergite also bearing a pair of long segmented hairs that split into four apical branches. Adult with the prealar sclerite membranous and without setæ; ninth sternite of the female distinctly sclerotized; male with the second (true second) palpal joint completely fused with the third; the phallosome with the lateral arms joined basally by a basal structure (the other Anophelini, all ?, have the lateral plates separated and widely diverging basally); a large dorsal phallosomic plate (= ? episome of Christophers) present.

If the condition of the phallosome and the palmate hairs indicate a primitive type (as well as the other apparently primitive features: dark color, rod-like erect scales on the occiput, and absence of scales on the thorax and abdomen) as one may suppose, it is strange to find the fusion of the second and third palpal joints in the male, which indicates a specialized structural condition. This shows, however, how irregularly specializations have occurred in the members of the tribe; the species tabulated above likewise show that the present-day species of Anophelini do not exhibit a uniformly graded series of specializations.

Most of the aberrent (and presumably the more primitive) types (i. e. those mentioned above) are placed in, or are considered to be closely related to the subgenus *Anopheles*, a group which by common concensus of opinion is regarded as one of the most primitive of the tribe. It is of interest to note that the species which appears to be most nearly related to *S. nimba*, namely *A. atratipes*, as indicated by structure (the figure given by Mackerras shows but two spines attached to the side-piece and the leaflets are attached to a rather large plate which may represent the dorsal plate of *S. nimba*) and somewhat by habits ("A sylvan day-biting species, most prevalent in spring and early summer" Mackerras) is an Australian species. Possibly we have here an argument in favor of the Antarctic region having been at a former time one of the centers of distribution for the Anophelini. It is also of interest to note that the other species with rudimentary palmate hairs occur in the Malayan region.

Genus **Anopheles**, Subgenus **Anopheles.**

Group **Manguinhosia** Lutz.

Manguinhosia Lutz, Um. Nov. Gen. Braz. Anoph. 1907.

The name *Manguinhosia*, established originally as a generic name for the reception of *M. lutzi* Cruz (= *Anopheles peryassui* Dyar and Knab, 1908) is here used as a group name solely as a matter of convenience for designating what may prove to be but a single species or else a group of closely related species. The fact that this species (or group of species) possesses characters which readily separate it from the groups *Patagiomyia* and *Arribalzagia*, its nearest allies, precludes the possibility of confusion with other Anophelines (see further discussion under *Anopheles minor* Costa Lima). The characters peculiar to the group are: abdomen without scales save on the eighth segment and the cerci and sometimes on the seventh; tarsi black with whitish rings (either apical and basal or apical only) except on the entirely black fifth joint; halteres without white scales; disk of mesonotum without developed scales.

SPECIES OF THE GROUP MANGUINHOSIA.

The status of the recorded species of this group is in a most unsatisfactory condition. On three occasions, specific names have been erected for material originating from various parts of Brazil: *peryassui* Dyar and Knab 1908 (= lutzi Cruz, 1907); *celidopus* Dyar and Shannon, 1925; *alagoanii* Peryassù 1925. In addition to the original records; Peryassù (1921) has recorded *peryassui* (as *lutzi* Cruz) from five different states of Brazil; Bonne and Bonne-Wepster (1925) have recorded the same species from Surinam; and we have at hand material from the States of Bahia and Recife which may prove to be any of the above or still another species.

The species of the group are evidently rare, and with the exception of *alagoanii*, males have not hitherto been recorded, and even in this case the terminalia are undescribed. Owing to the insufficiency of the characters presented by the females and to the possibility of the examples from Surinam being misidentified, it is impossible for the present to determine how many of the above should be recognized as valid species.

A brief historical review is here given for the forms involved.

(1). **A. (A. Manguinhosia) peryassui** Dyar and Knab, 1908.

Manguinhosia lutzi Cruz (not Cruz, 1901). Um. Nov. Gen. Braz. Anoph., 1907.
Anopheles peryassui Dyar and Knab. Proc. U. S. Nat. Mus. 25: 53, note, 1908.

Description based on females only. Type locality: Bicudos, State of Minas Geraes (June) (*vide* Peryassù, 1908). Recorded by Peryassù (1921) from the States of Bahia, Sao Paulo, Minas Geraes, Goyaz, and Matto Grosso.

Eight specimens, probably types now in very poor condition, are present in the collection of the Oswaldo Cruz Institute.

(1a) Bonne and Bonne-Wepster (1925) record several females of *Anopheles peryassui* from Moengo, Surinam. Dyar's description of *Anopheles* (*Anopheles*) *peryassui* D. and K. (1928) is presumably based on a specimen from Surinam.

(2). **A. (A. Manguinhosia) celidopus** Dyar and Shannon.

Anopheles celidopus Dyar and Shannon. Journ. Wash. Acad. Sci., 15: 41, 1925. (January).

Described from five females. Type locality: Carmo, Rio Branco, Amazonas. Type in the U. S. National Museum, Washington, D. C.

(3). **A. (A. Manguinhosia) alagoanii** Peryassú.

Anopheles alagoanii Peryassù, A. Folha Medica, 6: 258, 1925. (October).

Described from males and females (without description of terminalia). Type locality: "Captured along the margins of the lagoa Manguba and more abundant at Mutange and Bom-Parte, suburbs of the city of Maceió, capital of the State of Alagoas, Brazil. The larvæ inhabit boggy areas in the wooded valleys and swamps (June, July, August, and September)." Types presumably in the collection of Dr. Peryassù.

4. Present material from Bahia.

The larvæ were found on several occasions (March to May, 1929) in a small spring-fed swamp located about eight miles north of the city of Bahia. Adults of both sexes were reared and in addition fifteen females were taken in the locality while using a horse as bait. All stages, except the egg, are described below.

5. Two females collected in the outskirts of the city of Recife on a horse, October 20, 1929.

They agree in structure and coloration with those listed under number 4.

The original description of *peryassui* is not in accord with our specimens in several respects. It states that white rings are present at both ends of the joints: ("1st, 2d, 3d, and 4th segments of the tarsi with the same coloration, there being present on all a cream-colored ring, which involves both ends of the segments"). Also the description states that the halteres are dark with some yellow scales. Dr. A. da Costa Lima, who examined the specimens of *peryassui* in the Oswaldo Cruz Institute, informs us that our specimens differ from those in the Institute in one notable respect, namely, as regards the scaling on the abdomen. In *peryassui*, "next to the apical extremity of the seventh segment, on all the eighth, and on the genital segment, there are found *numerous white scales*, giving these segments an ashy appearance. On the apex of the seventh segment there are also some yellow scales. Lower surface: dark, clothed with light chestnut hairs, with some white, rounded spatulate scales on the seventh and eighth segments, with the genital lobes densely clothed with black, broadly spatulate scales. From my point of view, your specimens appear to be to *peryassui* as *brasilensis* is to *albitarsis*." (Costa Lima).

Our specimens from Bahia, differ from the above characterization in having only apical rings on the tarsal joints; the knob of the halteres completely black, a complete absence of scales on the seventh segment, both above and below, and in having bronze-colored scales intermixed with the white on the eighth segment, while the dorsal surface of the cerci is clothed with black and white scales.

Dyar (1928) separated the three described forms as follows (description of *peryassui* is probably based on a specimen from Surinam):

1. Wing spottings more relieved; distinct white scales preceding the last costal spot; tarsi with yellowish white narrow rings at the articulations involving both ends of the segments, less marked on the hind tarsi than on the fore and mid tarsi.............................*peryassui* D. and K.
   Wing spottings less relieved; no distinct white scales outwardly on costa; tarsal rings involving both ends of the segments.
2. Tarsal rings most prominent on the hind legs...........*alagoanii* Peryassú
   Tarsal rings most prominent on the fore legs...........*celidopus* D. and S.

In all cases, it has been recorded that the tarsal rings involve both ends of the segments, and for the first two, the rings are said to be less prominent on the hind than on the fore tarsi.

In the present Bahian material, the rings are apical only and but slightly more prominent on the fore legs than on the mid and hind legs.

If the above-mentioned differences were known to be constant, the forms no doubt could stand as good species and it would be justifiable considering our material as representing a new species. However, considering the lack of verified information; the unknown structure of the male terminalia of all but our own material, the distribution of the recorded material and their obvious close similarity, there appears, for the time being, but one decision to make, which is to consider all tentatively as one species, namely *peryassui*. It should be mentioned in this connection that Recife (from whence we have two specimens) is not far distant from Maceio (type locality for *alagoanii*) and is between Maceio and Rio Branco (type locality for *celidopus*).

The description given below for *An. peryassui* is based entirely on our material from Bahia and Recife.

Anopheles (A. Manguinhosia) peryassui.

Larva: Antenna with a small sub-basal five branched hair; inner anterior clypeals simple, well approximated; outer clypeals thickly branched with more than 50 ultimate branches; posterior clypeals small, with five branches; inner anterior thoracic hairs small with about seven slender branches; palmate hairs of the Arribalzagia type present on segments one to seven, those on segments one and two with slender leaflets; plumose hairs on lateral margins of segments one to three, double on segments four and five, the remainder single; pecten with alternating long and short teeth, the short ones only with marginal setulæ; seven to eight well developed grappling hairs.

Pupa: Trumpet prolonged posteriorly with a deep notch, similar to that found in the *Arribalzagia;* eighth abdominal spine simple; paddles much longer than broad, the rib slightly mesad of the middle; terminal hair simple; spines on exterior margin very minute, but the apical and almost the entire inner margin with a fringe of fine hairs.

Female: Rather small, grayish in general appearance with remarkably long legs. Occiput with white scales above, dark brown below, white setæ and scales between the eyes; palpus with outstanding blackish scales, a few white ones at apices of second and third joints; prothoracic lobes with a tuft of scales above; three upper and two mid-sternopleural setæ; abdomen without scales save for appressed white scales on the dorsum of the last segment, and black and white scales on its sternite; cerci densely black scaled; legs very long, black, showing white markings only at the apices of the tibiæ and as narrow white apical rings on all

but the last fifth tarsal segments; the rings on the fore tarsi being the most prominent. Knobs of halteres black. Wings with seven black costal spots; three black spots on the third vein, alternating with white ones of nearly the same length and four, sometimes five black spots on the sixth vein. Outstanding scales on the basal half of the fourth vein ovate.

Male terminalia: Side-piece short, rather thick; the style distinctly longer; appendicle short and thick; two parabasal spines, no internal spine (i.e. side-piece with only two differentiated spines); phallosome extends beyond the apical margin of claspette lobe, with four to five well developed leaflets, the apical ones being equal to one-half the length of the phallosome; claspette lobe short and broad, the outer spines three in number, slender and situated very close together; but one marginal spine.

An uncommon species, the larva of which were found associated with *Stethomyia nimba* in a small spring-fed swamp on the property of Sr. Fratelli Vita at Pirajá, about eight miles north of the city of Bahia. More than seventy larvæ have been found from which twenty adults were reared. Fifteen additional females were taken in the locality while using a horse as bait. Larvæ (from which adults were reared) have also been found in a sedge marsh and in a horsetail marsh (*Equisetum*) on the property of Dr. Barros Barreto, Pirajá (October). Two females were collected on a horse at Recife (October).

Anopheles (Anopheles) minor Costa Lima.

Anopheles maculipes of authors (not Theobald).
Anopheles (*Arribalzagia*) *minor* Costa Lima, Brazil Medica, Anno 43, No. 37, p. 1100, 1929.

This species has long been considered the same as that described by Theobald under the name of *maculipes*, 1903. The true *maculipes* has passed under the name *pseudomaculipes* Peryassù (1908), while the present species received the name *maculipes* by Knab (1913), his identification being based in part upon a specimen (presumably the present species) proceeding from the State of Rio de Janeiro. Root and Edwards have established the synonomy of *pseudomaculipes* with *maculipes* and recently Costa Lima has described the *maculipes* of the authors as new, under the name of *A. minor*.

Dyar (1928) states "There is no tangible difference between the female of this species (*maculipes* = *minor*) and *apicimacula;* but until the male of *maculipes* (= *minor*) is known, they cannot be considered identical." He figures the terminalia of a

specimen which he regarded as possibly "*maculipes*." However, the terminalia of *A. minor* proves to be quite distinct from both *apicimacula* and "*maculipes*" of Dyar, 1928.

The type description of *A. minor* is based on females. We have at hand, the larva, pupa, and male which are herein described. The larva and male show several peculiar features which do not enable one to place them readily in any of the groups at present recognized. The form described above as *A.* (*Manguinhosia*) *peryassui*, agrees in certain respects with *A. minor*. Dr. Root, to whom specimens were sent writes: "They (*peryassui* and *minor*) undoubtedly represent a transition between the 'Patagiamyia' group and the more typical 'Arribalzagias.' But the transition is so beautifully graded, and the two species so decidedly different in adult coloration that I doubt if it would be best to try to define them as a separate group."

Apparently *peryassui* and allies approach the Patagiamyia group, while *minor* approaches the *Arribalzagia* group.

Larva: Antennal hair sub-basal, delicate, with seven long branches; inner anterior clypeals approximated with scattered very fine branched hairs; outer clypeals with approximately fifty ultimate branches, but as a whole stouter than in *peryassui;* thoracic and abdominal hairs similar to those of *peryassui*, but the lateral hairs of segments four and five usually with three branches; in addition, the ventral side of the thorax and abdomen clothed with fine hairs (best seen in cast skins, see Figure 18); pecten with alternating long and short spines, the short ones with marginal setulæ which are more apparent than in *peryassui;* eight to ten grappling hairs present.

Pupa: Trumpet sub-quadrate, without a deeply incised notch; paddles distinctly broader than in *peryassui*, with a long series of well defined teeth at about the middle of the outer margin, apical margin with a fringe of fine hairs which extend but a short distance on the inner margin; apical spine of eighth abdominal segment simple.

Female: Rather small dark species with shorter and more abundantly white-marked legs than in *peryassui*. Palpi with erect black scales, with a few white ones at the bases of the fourth and fifth joints, apex of the fifth whitish; prothoracic lobes with black scales above, whitish ones below; anterior and lateral margins of the mesonotum with a few white scales; three upper sternopleurals, and three closely approximated mid-sternopleurals; abdomen without dorsal scales save for the tufts at the apical corners of the segments, and scattered white ones on the eighth; the cerci densely clothed with white scales above and black scales, more numerous on the seventh and eighth sternites; all the femora and tibiæ with numerous yellowish white spots; the pale rings of

the fore tarsi distinctly larger than on the mid tarsi, but otherwise the markings are similar, the joints having both basal and apical yellowish white rings, basal only on the fifth, the basitarsus in addition has numerous white spots; hind tarsi with the basitarsis speckled with white on the lower surface and with a white apical band, segments two, three and four with apical rings, the fifth entirely black. Costa with nine or ten black spots, and nine or ten white spots; third vein chiefly black scaled, white scales forming three of four small spots; sixth vein with five or six black spots. Outstanding scales on the fourth vein with truncate tips. Halteres with the upper surface entirely white-scaled (similar to typical *Arribalzagia*) the lower surface black.

Male terminalia: Ninth tergite well sclerotized with a pair of slender lobe-like processes; anal lobe entirely membranous; side-pieces thick, a little less than twice as long, as wide and a little shorter than the style; appendicle shorter than the width of the style; both parabasal spines ending in a sharp curved point; internal spine undifferentiated; claspette but little wider than high, with a deep median incision, forming a pair of ventral lobes each of which possesses two slender spines and the modified spines, which are coalesced into a stout club; phallosome with a well developed pair of apical leaflets, nearly equal in length to the club, and a variable number of much smaller leaflets, four to eight in number.

A. minor possesses the following more obvious characters which differentiate it from *peryassui*, its nearest known relative: The hairy larval skin (ventral surface), the sub-quadrate shape of the pupal trumpets and lack of a deep incision; stronger developed teeth and restricted fringe of fine hairs on the inner margin of the paddles; more extensively dark scaled wings and intensively spotted femora and tibiæ; upper surface of halteres white scaled; male terminalia with claspette lobe narrower and with the modified spines forming a distinct club.

The hairy condition of the larva is of rare occurrence in Culicid larvæ. Other known American species possessing this feature are those belonging to the genus Chagasia, and Aedes scapularis Rondani.

The writers have found the larvæ to date in only one locality. Here, in a certain fairly swift-flowing stream, they have at times been obtained in great abundance along the margins and in places where the water has been partially dammed by drift debris. They were also found commonly in rock pools in the stream beds, where the rocks form a series of small water falls, but were very rarely found in temporary rainpools. There have been taken a total of approximately 2,000 larvæ collected on several occasions during the months of January to June

1929. During the months of May and June (early winter) the larvæ were very scarce. About 300 adults have been reared. The females were also collected in numbers by using horses as bait. In addition, one female was collected on the laboratory grounds, in the city of Bahia, October, 1929.

The above-mentioned stream is located at Pirajá upon the property of Dr. Luiz C. A. de Barros Barreto, to whom we are indebted for the opportunity of making investigations there. Also, we are indebted to him for our first specimens of this species, collected at his instigation by the entomologist of the Saude Publica of Bahia, Dr. Jose Serafim.

Anopheles (Arribalzagia) intermedius Peryassù, 1908.

A series of thirty females of this species were obtained on a horse at Pirajá (B. B.) Bahia during December, 1928. Later, on two different occasions, February and April, 1929, 18 larvæ were collected, from which four males were reared. The terminalia of these agree exactly with those of a specimen from Magé, Brazil (collection of N. C. Davis). On October 12 and 13, four additional females were collected on a horse at Pirajá.

Anopheles (Arriba lzagia) mediopunctatus Theobald, 1903.

Three females were captured on a horse December 27, 1928, at Pirajá (Barros Barreto), and on October 12 and 13, 1929, nine additional females were obtained on a horse in the same locality.

Anopheles (Kerteszia) cruzii Dyar and Knab, 1908.

This is a comparatively rare species in the vicinity of the city of Bahia. Dr. Serafim collected larvæ from bromelias near the town of Muricura, about twenty miles north of Bahia. Later, additional material was obtained by the writers from the same locality.

ANOPHELINES OF THE NYSSORHYNCHUS GROUP.

Four species of this group are at hand. The foregoing species were found only outside of the city limits of Sao Salvador, but, in the case of the species of the *Nyssorhynchus* group, although they have likewise been found outside of the city, most of our collections have been made within the city limits.

More or less rural conditions prevail in various parts of the city, such as valleys with streams, small marshy areas and ponds, springs, wells, etc., some of which afford good larval habitats. *A. argyritarsis* is more semi-domesticated than the other species, its larvæ being found not infrequently in artificial containers and adults have been found in houses on a number of occasions.

Anopheles (Nyssorhynchus) bachmanni Petrocchi.

Larvæ of this species have been found on two occasions, both times within the city limits: Distrito dos Mares (August 28, 1929) and Distrito do Tororó (November 4, 1929), N. Cerqueria, collector. This species has also been collected by the writers in Recife, Pernambuco, September and October, 1929.

Anopheles (Nyssorhynchus) tarsimaculatus Goeldi, 1906.

Larvæ of this species have been found, sometimes in large numbers, in the streams in and about the city of Bahia. During early winter (June 14) about 300 larvæ were obtained from a pond which at the same time yielded only a few *argyritarsis*. Also on other occasions when collections were made during the winter, larvæ of this species out-numbered the larvæ obtained of *albitarsis* and *argyritarsis*. Specimens have been found in Recife, Pernambuco, in September and October, 1929.

Anopheles (Nyssorhynchus) albitarsis L. A., 1878.

Next to *argyritarsis*, this is the most prevalent and abundant species during the warmer seasons in the vicinity of the city. The larvæ are usually found in ponds and temporary pools. On one occasion a female was captured in a house in the center of the city of Bahia, May 27, 1929.

Superficially, the adult greatly resembles *argyritarsis* and its resemblance to *darlingi* is even greater. As these species are somewhat variable as regards coloration, it becomes a difficult matter to identify worn females. However, *albitarsis* possesses a well defined characteristic (hitherto unrecorded) not present in any other American Anopheline, at least of the subgenus *Nyssorhynchus*, and may be detected regardless of the condition of the specimen, providing the base of the abdomen is intact. This character consists of two longitudinal and

parallel lines of white scales on the first abdominal sternite. If the specimen is badly shriveled, this character is difficult to see, but a caustic preparation under the microscope reveals both the scales and their scars. *A. argyritarsis*, and the other species of *Nyssorhynchus*, have this sternite bare save for the extremely short and fine pubescence. Also collected in Recife, Pernambuco, September and October, 1929.

Anopheles (Nyssorhynchus) albitarsis,
variety brasilensis Chagas, 1907.

To date authenticated specimens have been recorded only from the type locality, the valley of the Rio das Velhas, near Lassance in the State of Minas Geraes.

Larvæ, from which adult males and females were reared, were collected in the spring waters at the head of the spring-fed swamp in Pirajá (Fratelli Vita) March 1, 1929. On March 20 ten females were collected in the same locality on a horse used as animal bait. The specimens agree well with the description of the variety as given by Root (1926) except that the terminal hair of the paddle is straight and not bent, as recorded by Root. It agrees with typical *albitarsis* in possessing the two parallel lines of scales on the first sternite. Larvæ were later obtained at Pirajá (Barros Barreto) associated with larvæ of *A. peryassui* and *tarsimaculatus*.

Anopheles (Nyssorhynchus) argyritarsis R. D., 1827.

In Bahia this species is semi-domestic both in the larval and adult stages. During the warmer season, the larvæ probably can be found in all of the streams, springs, and ponds in and around the city, and rather frequently have been found in cisterns and smaller artificial containers, flower-pots, basins, etc. On several occasions females have been found in the houses located on the outskirts of the city.

Specimens also at hand from Recife, Pernambuco.

One or more of the following species may eventually be found in the coastal lowlands in the vicinity of the city of Bahia: *darlingi*, *maculipes*, and *eiseni*.

SUMMARY.

Twelve species of the Anophelini are now known from the State of Bahia, ten of which are here recorded from the capital (Sao Salvador or Bahia) and the immediate environs. Three additional species are listed which may eventually be found in the locality.

Three of the species, *Stethomyia nimba* Theo., *Anopheles minor* Costa Lima, and the third which is here recorded tentatively as *Anopheles* (*A. Manguinhosia*) *peryassui* D. and K. have hitherto been more or less unknown in the larval, pupal, and male stages and are therefore described in detail.

S. nimba differs so strikingly from the other known Anophelines in the structure of the phallosome and other male and larval characteristics that it is here accorded generic rank. It is shown it has no close relations with the other American Anophelines but apparently possesses rather close relations with certain Australian and Malayan Anophelines; therefore, it possibly represents an isolated form of a group which had its center of distribution in a former Antarctic continent.

BIBLIOGRAPHY.

Bonne, C. and **Bonne-Wepster, J.** 1925. Mosquitos of Surinam, a Study on Neotropical Mosquitos. Royal Col. Inst. of Amsterdam, No. 21, Department of Tropical Hygiene, No. 13.

Bourroul, C. 1904. Mosquitos do Brazil. Faculdade de Medicina da Bahia. Thesede Doutoramento, Bahia, Brazil.

Chamberlain, W. P. and **Curry, D. P.** 1928. Mosquito and Malaria Control Work. Rep. Hlth. Dept. Panama Canal, 1927: 17–21.

Christophers, S. R. 1922. The development and structure of the terminal abdominal segments and hypopygium of the mosquito, with observations on the homologies of the terminal segments of the larva. Indian Journ. Med. Res. 10, No 2: 530–571.

Christophers, S. R. 1924. Provisional list and reference catalogue of the Anophelini. Indian Med. Res. Mem. No. 3.

Christophers, S. R. and **Barraud, P. J.** 1923. Descriptive terminology of male genitalic characters of mosquitos. Indian Journ. Med. Res. 10: No. 3, 827–835.

Crampton, G. C. 1925. A phylogenetic study of the thoracic sclerites of the non-tipuloid nematocerous Diptera. Ann. Ent. Soc. Amer., 18: 49–69.

Davis, N. C. 1926. Notes on the female hypopygia of Anopheline mosquitos, with special reference to some Brazilian species. American Journ. Hyg. 6: 1–22, (March supplement).

Dyar, H. G. 1918. Notes on American Anopheles. Ins. Ins. Mens. 6: 141–151.

Dyar, H. G. 1928. The mosquitos of the Americas. Carnegie Institution of Washington.

Edwards, F. W. 1920. The nomenclature of the parts of the male hypopygium of Diptera Nematocera, with special reference to mosquitos. Ann. Trop. Med. and Parasit., 14: 23–40.

Edwards, F. W. 1921. A revision of the mosquitos of the Palaearctic region. Bull. Ent. Res., 12: 263–351.

Edwards, F. W. 1924. A synopsis of the adult mosquitos of the Australasian region. Bull. Ent. Res., 14, 4: 351–401.

Ferris, G. F. 1929. The principles of systematic entomology. Stanford University Press, California.

Ferris, G. F. and **Chamberlain, J. C.** 1928. On the use of the word "Chitinized." Ent. News, 39, 7: 212–215.

Freeborn, S. B. 1924. The terminal abdominal structures of male mosquitos. Am. Journ. Hyg. 4, 3: 188–212.

Gater, B. A. R. 1929. An improved method of mounting mosquito larvæ. Bull. Ent. Res., 19, 4: 367–368.

Imms, A. D. 1929. Some methods of technique applicable to entomology. Bull. Ent. Res., 20, 2: 165–171.

Mackerras, I. M. 1927. Notes on Australian mosquitos. Part I. The Anophelini of the Mainland. Proc. Linn. Soc. N. S. Wales, 52, 2: 33–41.

Peryassu, A. G. 1921. Os Anophelineos do Brazil. Arch. Mus. Nac. Rio de Janeiro, 23: 1–100.

Root, F. M. 1926. Studies on Brazilian mosquitos. I. The Anophelines of the Nyssorhynchus group. Amer. Journ. Hyg. 6, 5: 684–717.

Root, F. M. 1927. Studies on Brazilian mosquitos. II. *Chagasia fajardoi.* Ibid., 7, 4: 470–480.

Root, F. M. 1927. Studies, etc. IV. Notes on some Brazilian species of Anopheles. Ibid, 7, 5: 599–605.

Root, F. M. 1929. In Hegner, Root and Augustine, Animal Parasitology: 483–502.

Snodgrass, R. E. 1929. Some further errors of body wall nomenclature in entomology. Ent. News, 40, 5: 150–155.

EXPLANATION OF PLATES.

All drawings made with the aid of the camera lucida.

PLATE I.

Fig. 1. Larva of *Stethomyia nimba*, with an enlargement of one of the filamentous palmate hairs and of the pecten.

PLATE II.

Fig. 2. Pupa of *Stethomyia nimba*, with the cephalo-thorax opened along the median dorsal line.

PLATE III.

Fig. 3. Mental plate, larva of *S. nimba*.
Fig. 4. Maxilla, larva of *S. nimba*.
Fig. 5. Mandible, larva of *S. nimba*.
Fig. 6. Respiratory apparatus, larva of *S. nimba*.
Fig. 7. Segmented hair of respiratory apparatus enlarged, larva of *S. nimba*.
Fig. 8. Ninth tergite and anal lobe of male of *S. nimba*, flattened condition.
Fig. 9. Dorsal aspect of apex of phallosome of *A. punctipennis*, showing the leaflets attached to transparent structure, (the episome?).
Fig. 9a. The same, but from an end-on view.
Fig. 10. Terminalia of *S. nimba*, female.

PLATE IV.

Fig. 11. Terminalia, *S. nimba*.
Fig. 12. Claspette and phallosome, end-on flattened view, *S. nimba*.
Fig. 13. Same, dorsal view.
Fig. 14. Phallosome, ventral view, *S. nimba*.
Fig 15. Terminalia, *A. peryassui*.
Fig. 16. Terminalia, *A. minor*.

PLATE V.

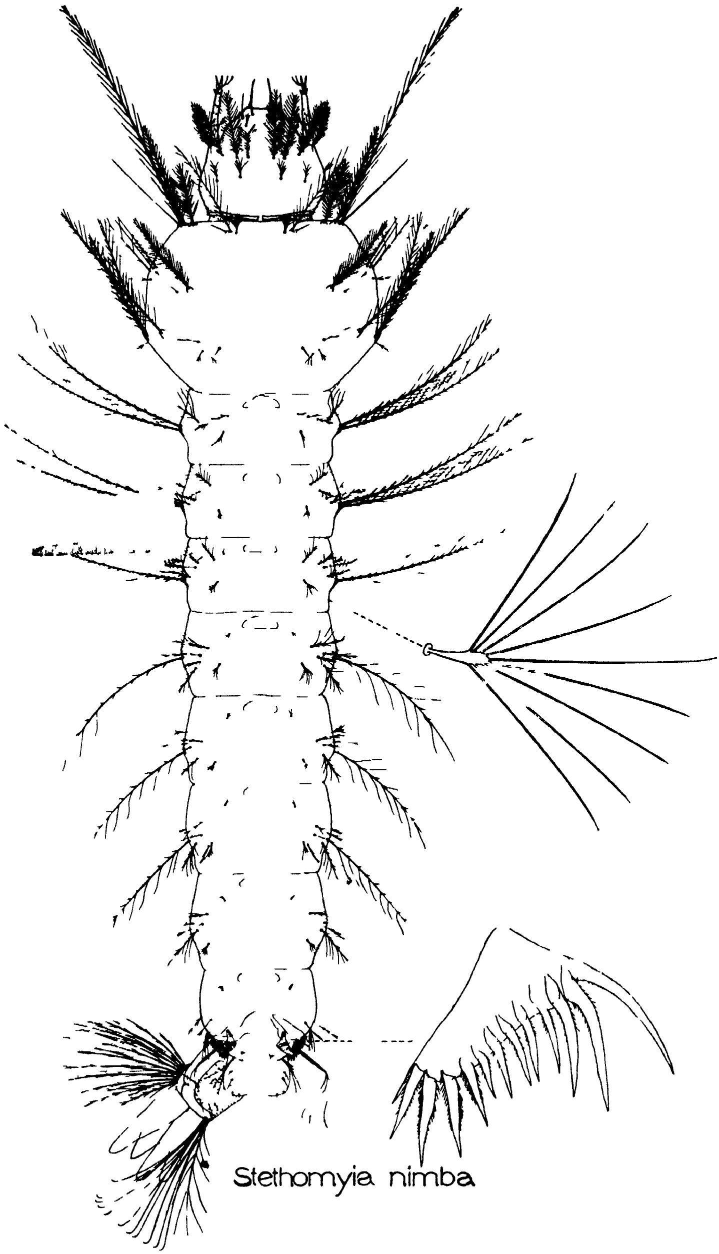
Fig. 17. Larva of *A. peryassui* with enlargement of clypeal and palmate hair and pecten.

PLATE VI.

Fig. 18. Section of the thorax of the larval skin of *A. minor*, showing distribution of the minute hairs on the ventral surface
Fig. 18a. Outer clypeal hair of the larva of *A. minor*.
Fig. 19. Pupal trumpet of *A. peryassui*.
Fig. 20. Abdomen of the pupa of *A. peryassui*.
Fig. 21. Pupal trumpet of *A. minor*.
Fig. 22. Terminal abdominal segments of the pupa of *A. minor*.

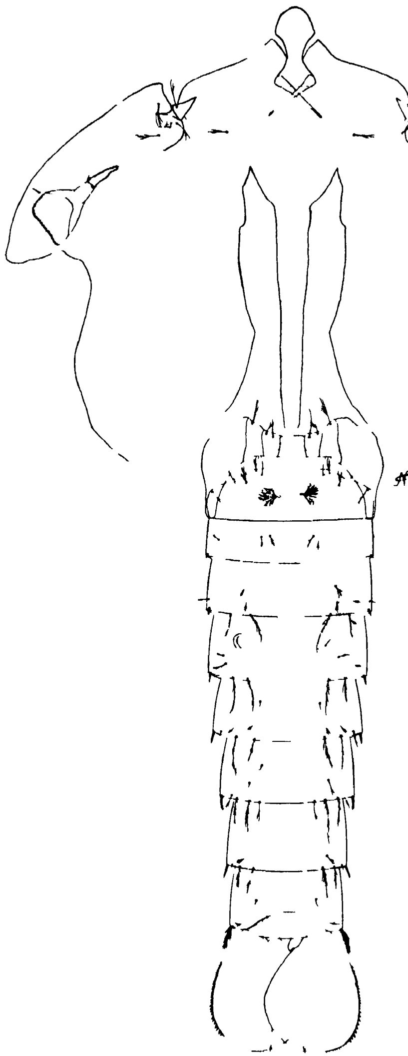
PLATE VII.

Fig. 23. Side view of the thorax of *S. nimba*. The small circles indicate the location of the pleural setæ.
Fig. 24. The same of *A. peryassui*.
Fig. 25. Distribution of the dark scale areas on the wing of *A. minor*.
Fig. 25a. Enlargement of the base of the fourth wing vein, showing the form of the scales.
Fig. 26. Distribution of the dark scale areas on the wing of *A. peryassui*.
Fig. 26a. Enlargement of the scales on the base of the fourth vein, *A. peryassui*.
Figs. 27 and 27a. Fore and hind tarsi of *A. peryassui*.
Figs. 28 and 28a. Fore and hind tarsi of *A. minor*.

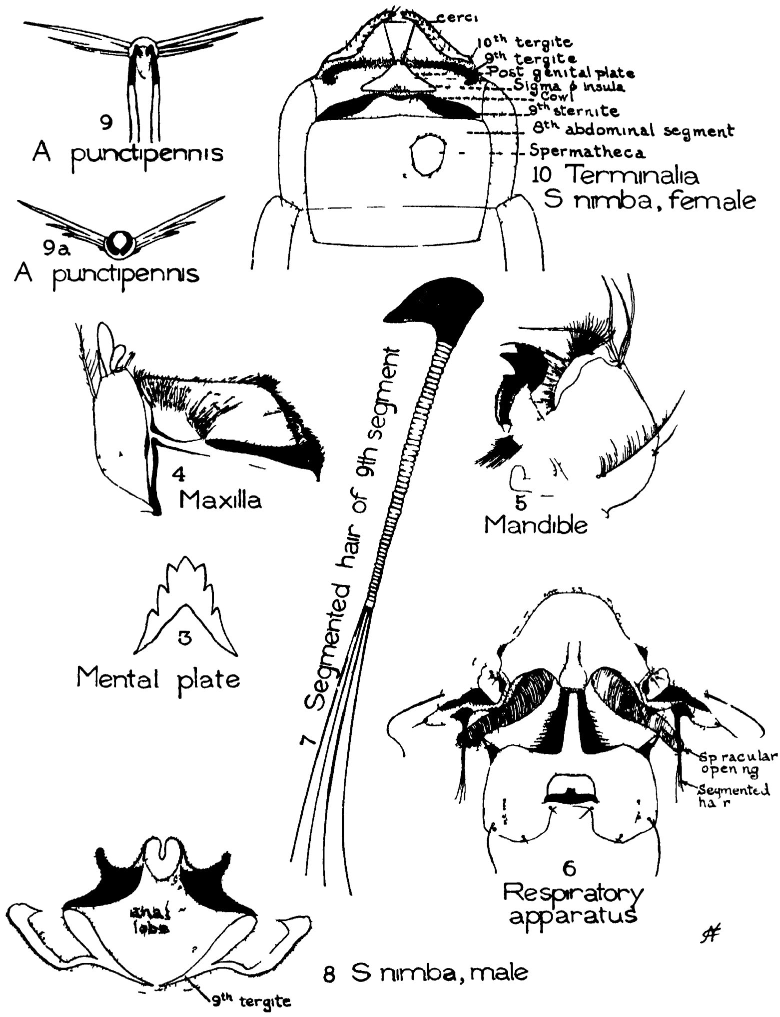


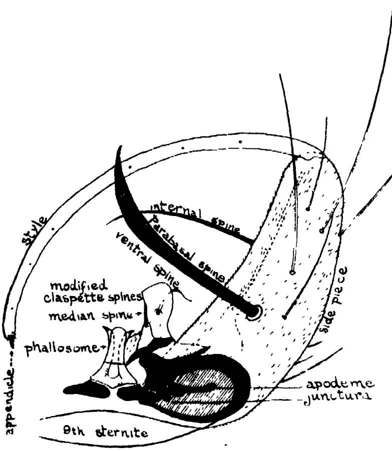
Stethomyia nimba

Nelson Cerqueira, del

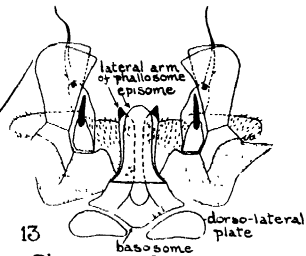


2 Stethomyia nimba

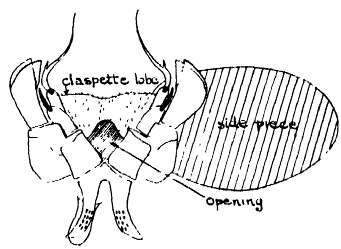

cerci
10th tergite
9th tergite
Post genital plate
Sigma & insula
Cowl
9th sternite
8th abdominal segment
Spermatheca
10 Terminalia
S nimba, female
9
A punctipennis
9a
A punctipennis
4
Maxilla
7 Segmented hair of 9th segment
5
Mandible
3
Mental plate
Spiracular opening
Segmented hair
6
Respiratory apparatus
anal lobe
9th tergite
8 S nimba, male



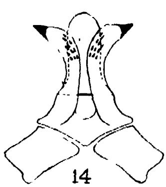
11 Terminalia, S. nimba



13 Claspette & phallosome

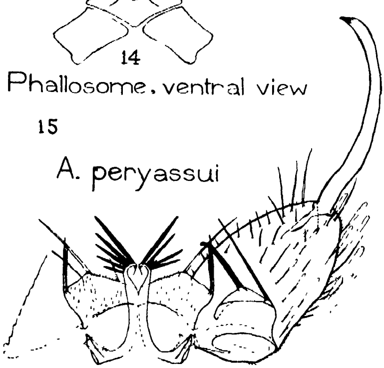


12 Claspctte & phallosomc,

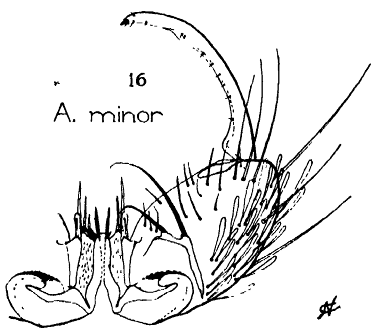


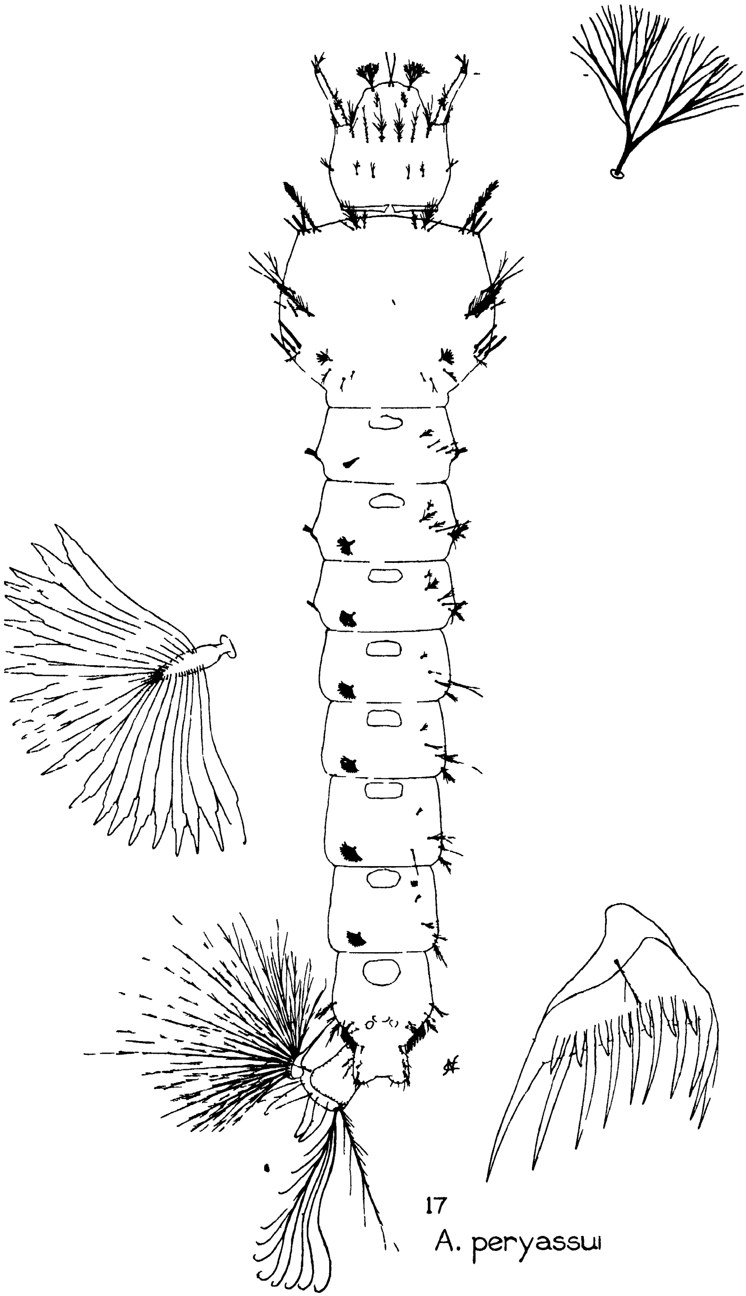
14 Phallosome, ventral view

15 A. peryassui

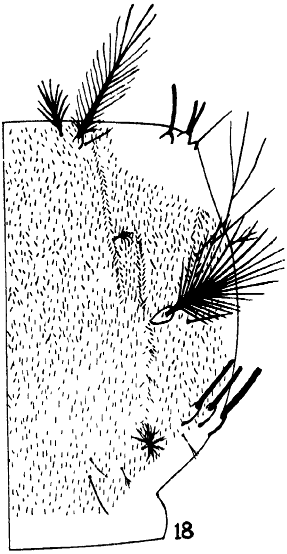


16 A. minor



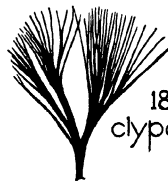


17
A. peryassui

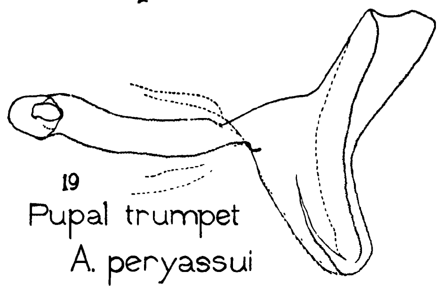


18

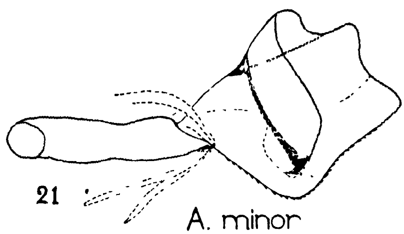
Thorax of larva A. minor



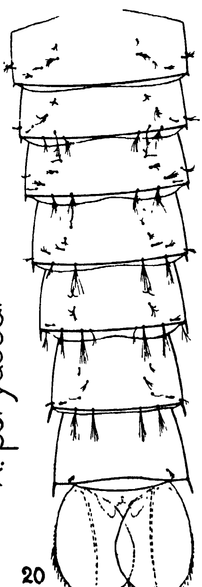
18a Outer clypeal hair, A. minor



19 Pupal trumpet A. peryassui

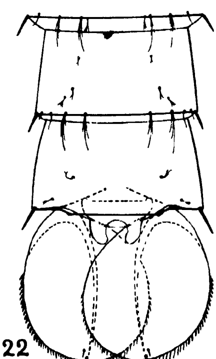


21 A. minor

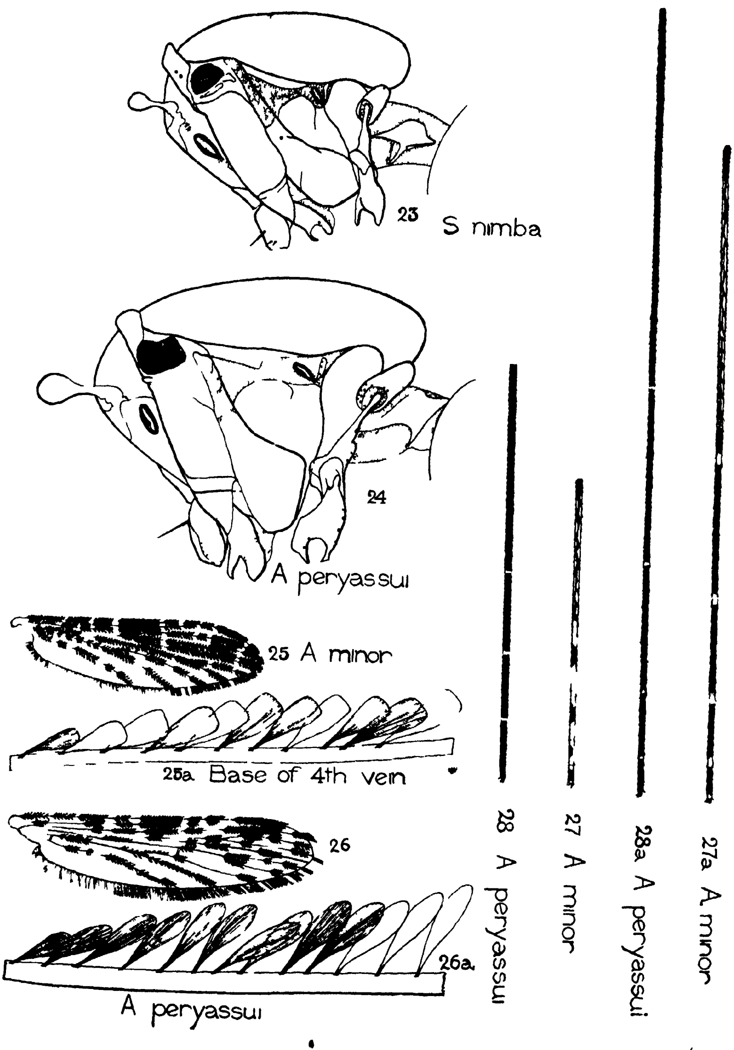


A. peryassui

20 Abdomen of pupa



22 A. minor


23 S nimba
24
A peryassui
25 A minor
25a Base of 4th vein
26
26a
A peryassui
28 A peryassui
27 A minor
28a A peryassui
27a A minor

...R IMPORTANCE WHICH ...ADE TO THE STUDY ...CTS.

...t its Twenty-fourth Meeting, ..., Iowa.)

...ONOMY OF INSECTS.*

... Mickel,
... Minnesota.

... America may be said to have had ... Say, who published his first paper ... f the Academy of Natural Science ... of Several New Species of North ... er may be looked upon as the ... erica, there is at least one earlier ... contribution to taxonomy, that of ... ue of the Insects of Pennsylvania." ... tributing much of scientific value, ... andpoint since it represents one of ... American insect fauna. It is said ... shed in America, of a Coleopterous ... attempt in the realm of taxonomy ... Entomology," the purpose of ... nd species of the insects of the ... gravings." The work advanced ... ur colored plates, and was then ... ana before the publication of the third volume and after the latter was published the work was discontinued either because of the difficulty in conferring with him, or because of lack of public patronage, or perhaps both. Judged by its

*Published with the approval of the Director as Paper 211 of the Miscellaneous Series of the University of Minnesota Experiment Station.

purpose and contents Say's "American Entomology" compares very favorably with similar works published in other countries at that period. Contributions to the science of entomology were not numerous in the United States prior to 1860. Some of the earlier workers contemporaneous with Say were Thaddeus William Harris, John Eatton LeConte and Titian R. Peale, while during the latter part of the period John L. LeConte, S. S. Haldeman and F. E. Melsheimer were making contributions.

Taxonomic work on a productive scale did not begin in America until after the Civil War. From 1864 until the present time there has been a steady increase in the contributions by Americans to this branch of entomology. This growth in quantity of contributions by American workers can be readily demonstrated by a study of the entries in the Zoological Record at ten-year intervals. The first volume of the Zoological Record contains a list of the entomological publications for the year 1864. Since the majority of the papers listed in the Record are of a taxonomic nature, it seems fair to use it for the purpose of calculating the growth in America of taxonomic literature in the field of entomology. In 1864 the number of papers listed on entomological subjects was 323. Of these 36, or 11 per cent, were produced in the United States or Canada. The figures for 1870 and ten year intervals thereafter are as follows:

Year	Total Number Papers on Entomology	Number Produced in America	Per Cent Produced in America
1864	323	36	11
1870	438	31	7
1880	378	49	13
1890	927	137	14 7
1900	1,431	234	16.3
1910	3,232	632	19.5
1920	1,932	470	24.3
1927	2,923	712	24.3

Thus from the viewpoint of quantity American workers have produced almost one-fourth of the literature listed in the Zoological Record in recent years and it seems reasonable to assume that this proportion probably holds in the limited field of taxonomy. The proportions which various continental regions of the world contributed to entomological literature in 1927 are as follows: A total of 2,923 papers are listed; of these, 1,897 or 64.8 per cent had their origin in Europe; 712 or 24.3 per cent were produced in the United States and Canada; 143 or 4.8 per cent came from Asia; 80 or 2.7 per cent originated in Australia; 70 or 2.4 per cent were written by South American workers; and 21 or .7 of one per cent came from Africa. From a purely quantitative standpoint, then it appears that the workers in United States and Canada can contemplate their record in the field of taxonomy with some degree of satisfaction, since in approximately one hundred years their productivity has increased from nothing at all, to almost twenty-five per cent of the world's literature on the subject. It should be borne in mind that this has come about during a period when a large proportion

of the workers in Europe were engaged in taxonomic studies while in America a great number of workers have been engaged partially or entirely in developing the field of economic entomology.

From a qualitative standpoint contributions to entomological taxonomy can be classified according to type. So we have Catalogues; Nomenclatorial works; Codes of nomenclature; Local geographical lists; Descriptions of species; Synopses of groups of insects; Taxonomy of immature stages of insects; Monographic treatments of genera and higher groups; Discussions of classification and phylogeny; and Formulation of principles.

Most of the catalogues that have been produced in this country have had to do almost exclusively with North American insects. Some of the larger and more inclusive ones are Henshaw's check list of North American Coleoptera, and the more recent Coleoptera check list by C. W. Leng; the catalogues of Lepidoptera by H. G. Dyar, and by Barnes and McDunnough; Aldrich's catalogue of North American Diptera; the catalogue of Odonata by Muttkowski; that of the Coccidæ by Mrs. Fernald; and the catalogue of Hemiptera by Van Duzee. Recently a general catalogue of the Hemiptera of the world has been undertaken, sponsored by Smith College. America's contribution to that great work, "Genera Insectorum," should also be mentioned here. To date some 189 fascicles have been published, 19, or 10 per cent of them by American workers, namely, Alexander, Brues, Caudell, Johannsen, Kellogg, Melander, Pierce, Quaintance and Rehn.

The outstanding American contribution in the nomenclatorial field is Scudder's "Nomenclator Zoologicus." Although this work covers the whole field of zoology, entomologists may properly regard it as originating in their field, since it was written by an eminent entomologist.

American entomologists are, of course, guided by the International Code of Nomenclature in solving their problems relative to scientific names, and yet there are cases which often arise that are not specifically covered by the International Rules. To fill the need in such cases America has contributed an Entomological Code of Nomenclature compiled by Nathan Banbs and A. N. Candell, which represents the usage and customs of a large number of entomologists for the time it was written. While this code does not have the authority of the International Rules, yet it is a distinct contribution in this particular field and many an entomologist has found it useful in working out his nomenclatorial problems.

It is probable that the number of local geographical lists of insects which have been published in this country would mount to a large figure, but two such lists stand out as the most comprehensive which this country has produced. These are the "Insects of New Jersey," and "A List of the Insects of New York."

It is evident to anyone acquainted with entomological literature that the great bulk of such literature is made up of descriptions of species. This is true of our American contributions as well as of those from other parts of the world, and is necessarily so, since so large a portion of the insect fauna of the world still remains to be described.

A large proportion of the taxonomic papers which have been produced in this country will be found to consist entirely of descriptions of new species and nothing more. To single out certain of these papers and credit them with being important contributions is an impossible task, and I shall not attempt it, since we are not even at an agreement among ourselves as to what kind of a description is the best.

In the field of taxonomy, works which attempt a synopsis of large groups of insects are often indispensable. Some of the more important works of this type are Williston's "North American Diptera," Holland's "Butterfly Book" and "Moth Book," Howard's "Insect Book," Kellogg's "American Insects," and Essig's "Insects of Western North America." Every entomologist has had and will have occasion to refer to all of these works, and they fill an important place in the realm of taxonomy.

One of the phases of taxonomy with which many entomologists are not as familiar as they should be and to which America has made a distinct contribution is the classification and study of the immature stages of insects with complete metamorphosis. Some of the most notable contributions of this type are Fracker's "Classification of Lepidopterous Larvæ," Mosher's "Classification of Lepidoptera based on the Pupa," Malloch's "Classification of the Diptera based on Larval and Pupal Characters," Yuasa's "Classification of the Larvæ of the Tenthredinoidea," and Craighead's study on "North American Cerambycid Larvæ." There is still ample opportunity for contributions in this field and the need for work of this kind becomes more and more pressing with every new development in the field of economic entomology.

American workers have produced a great number of monographic works treating of genera or higher groups for North America north of Mexico or for even more limited geographical areas on the North American continent Time does not permit a review of all the good entomological monographs on North American insects, nor is it possible to scan all such contributions and judge of their scientific worth. In most cases it is necessary to have a working knowledge of a genus or higher group in order to be competent to judge the scientific value of any contribution concerning that group, and it is therefore impossible for a single person to select and mention all the important contributions of this type. From the standpoint of comprehensiveness and general usefulness, however, there are a number of works that might be mentioned. Some of these are: the "Mosquitoes of North and Central America and the West Indies," by Howard, Dyar and Knab; Edward's "Butterflies of North America;" "Monographs of North American Diptera," by Osten Sacken; LeConte and Horn's "Classification of the Coleoptera of North America," and "Rhynchophora of America North of Mexico;" "Butterflies of Eastern United States and Canada," by Scudder; Blatchley's "Orthoptera of Northeast America," "Coleoptera of Indiana" and "Heteroptera of Eastern North America;" the "Plecoptera of North America," by Needham and Claasen; "Handbook of Dragonflies of North America," by Needham and Heywood; Hagen's

"Synopsis of the Neuroptera of North America," and the series of works published by the Connecticut Geological and Natural History Survey, "Orthoptera of Connecticut," "Hymenoptera of Connecticut," "Hemiptera of Connecticut" and "Odonata of Connecticut." Any entomological taxonomist will no doubt call to mind at once contributions in his own particular field that seem to him as important, or perhaps more important, than the ones mentioned, and he may perhaps judge the ones with which he is familiar to be of greater scientific worth than those just enumerated, but judged from the standpoint of usefulness to entomologists as a whole, most taxonomists will agree that these are at least some of the important contributions which Americans have made in this field.

In the field of classification and phylogeny we find that Americans have also been active. The systems of classification in use at the present time for at least three large orders of insects have originated in this country. One of the first to make a contribution was John L. LeConte, who proposed a system for the classification of the Coleoptera in 1861, and completed it in collaboration with Horn in 1883. This system has been almost universally used in this country, although encountering some criticism abroad. In 1920 LeConte's system was modified by Leng and the classification of this order used by the latter in his catalogue of North American Coleoptera is the one now met with in current literature. Again, the classification of the Hymenoptera now in use in many parts of the world was proposed by Ashmead in 1899. Ashmead also made a number of contributions regarding the classification of the various superfamilies of the Hymenoptera. Many criticisms have been directed against Ashmead's work, and it must be admitted that in many ways it does not exhibit the scientific accuracy that one might expect, nevertheless, the classification he proposed has been adopted in its general outlines and stands as a distinct contribution to the classification of this order of insects. The division of the Lepidoptera into two suborders, Jugatæ and Frenatæ, dates from Comstock's work on wing venation in 1893, and since that time several other American Lepidopterists have contributed to the classification within the order. Mention should also be made of Crampton's papers on the phylogeny of the orders of insects. Crampton's work is of course based on morphology, but its application lies in the field of taxonomy. The system of classification of the insects in use at present is that proposed by Brauer in 1885 and modified by various workers since it was first proposed. While Crampton's ideas have not been adopted by the author of any recent textbook on the insects, yet they represent a contribution to this field which cannot be ignored by any future student of the phylogeny of the insects.

Taxonomic workers in both Europe and America have been so engrossed for the last century in describing, classifying and analyzing their material that there has been very little attempt during that period to formulate the principles on which their science is based. It has remained for America to contribute the first work which attempts to set forth the principles governing the science of systematic entomology.

This has been done by G. F. Ferris in his recent text, "Principles of Systematic Entomology." It is a curious fact that although taxonomy was one of the first phases of entomology to be developed in Europe, the first attempt at a formal statement of principles of entomological taxonomy has been made in America. On the other hand, economic entomology has had its greatest development in America, and yet it has happened that the first formal statement of principles of that branch of the science originated in Europe. I refer to Wardle and Buckle's "Principles of Economic Entomology."

All taxonomists as well as workers in other branches of Entomology have to make a beginning in the field. To furnish a guide to the beginner and often to the professional entomologist as well, America has produced several textbooks which are fundamentally taxonomical in nature and which compare favorably with those that have been produced elsewhere in the world. The first important American textbook of this kind was Packard's "Guide to the Study of Insects." Later came Comstock's "Manual for the Study of Insects," which has been superseded by the same author's "Introduction to Entomology." These are contributions in which any American may take pride, and while they may not be looked upon as taxonomic contributions in the technical sense, they have certainly contributed an important part in developing an interest, and in training workers in systematic entomology.

To summarize briefly, entomological taxonomy in America has grown in quantity during a period of one hundred and ten years from a stage when practically none of the taxonomic literature of the world was produced in this country, to a point where almost twenty-five per cent of the contributions originate here. From a qualitative standpoint American workers have made important contributions to all types of taxonomic investigation. Their contributions have varied with regard to their scientific worth, some of doubtful value, some of very high value, and all intergrades between, but a large number of their contributions have been recognized and will continue to be looked upon as having attained a high standard of perfection. It is probable that the percentage of taxonomic papers in America which have attained a high standard of scientific worth is about the same as for any other geographical group which one might select. Surveying the field of entomological taxonomy as a whole and considering its broadest aspects, America's most significant contribution, however, is not to be found in the work of any one individual, or in any particular type of taxonomic endeavor. With the possible exception of Europe no other great land mass of the world such as the United States and Canada has been so intensively studied and explored with regard to its insect fauna. Our detailed knowledge of the insect fauna of other continental regions of the world is far behind that of Europe and North America north of Mexico. By far the greater part of the study and exploration of the insect fauna of the United States and Canada has taken place during the last century and it is a distinct and significant contribution to our taxonomic knowledge of the insects of the world. Much still remains to be done and the success of the last century should stimulate us to still greater and better researches in the field of taxonomy.

CONTRIBUTIONS TO BIOLOGY OF INSECTS.

DWIGHT M. DELONG,
Ohio State University.

Biology, Ecology, and Physiology have been placed under separate headings in this symposium and are being treated in different papers. Biology, however, can be discussed intelligently only in terms of these other subjects. For at least a half century we have been making detailed life history and biologic studies of a host of interesting and important species of insects. These studies, in reality, have been more or less complete observations of a succession or series of reactions to a variety or complex of internal and external stimuli. Hibernation is a response to atmospheric stimuli, directly and indirectly. The insects activities in the spring usually begin by responses to the same types of stimuli and the insect comes from hibernation. The flight to the food plant is a specific response. Mating, egg laying, hatching of the egg, feeding, growth, pupation, emergence, and every portion of the biologic record is a reaction to a stimulus, chemical or physical. These are the phenomena we observe in biologic work yet none of these data can be obtained without certain ecologic conditions and physiologic processes. If factors cause certain stimuli to vary or alter the complex, the biology is changed.

The importance of the physiologic is in connection with metabolism. The environment alters metabolic rate and the biology is normally an activity index and transposition of metabolic rate. Therefore biology and metabolic rate are not only inseparable, but are different means of expressing the same process. Rate of respiration, quantity and quality of food, oxidation and consequently growth and activity are fundamentals of biologic study.

In the more important contributions of our biologic work the investigator has made a record of such insect activities in relation to the conditions in which it naturally occurs and has attempted so far as possible to measure or explain conditions associated with or determining these activities.

As a rule temperature and humidity conditions are recorded as a portion of the life history data. Occasionally measurements of light are given to explain certain phases of the life cycle, such as migration—although very little is known about light in its relation to biology. On the other hand, the plant and its processes during growth as factors in insect biology have received a minimum of attention and have been touched upon only in recent work. Even so, the plant factor is apparently the controlling stimulus in some cases and more important directly than the combined atmospheric stimuli, except as they affect the plant. Chemical and physiologic changes or processes in the plant may thus determine the hatching of the egg or the number of generations of the insect. Taking one of the leafhoppers as a specific example, we observe

an insect which lays its eggs in the twigs of a deciduous tree. This tree produces a flush of growth in early spring and remains without producing further visible growth throughout the summer. The insect has a single generation which occurs in connection with this flush of growth and lays eggs shortly after the adult stage is reached in late June and early July. The adults then disappear and are not seen on this plant until the next spring when they again occur in great swarms. Although almost every degree of high summer temperature and humidity are reached during July, August, September and October in this latitude of 39 degrees, these eggs do not hatch until the plant grows again. A two or more generation condition apparently exists on other deciduous host plants which grow gradually over a longer period, if we may judge from the fact that immature forms occur upon them all summer. It is apparent from these observations that an internal plant stimulus associated with growth is necessary in this case for the hatching of the egg; and temperature and humidity are of no consequence without the plant factor.

In plants from day to day sugar content, osmotic pressure, rate of transpiration, and as a result cell structure, tissue differentiation or cuticular conditions change remarkably. The biology of the insect seems to be definitely associated with these changes, certain combinations being favorable and certain unfavorable to the establishment or maintenance of insect populations. Insect migrations for instance are apparently caused by these changing plant factors.

Alternation of Food Plants.

In connection with the life history the studies of the alternations of food plants have been interesting and important contributions It is a well known fact that many insects like the aphids have definite food plants between which they alternate during their life cycle. These plants are usually not related botanically and the factors of attraction have been an interesting query. Most of these insects have a definite correlation between the plant process and their period of migration so that migration usually occurs within definite and limited periods. The aphids on the apple, for instance, seem to migrate at specific times. Observations over a period of years have shown that the migration of the apple grain aphis is correlated with the petal fall condition, while the migration of the rosy apple aphis occurs later, when the fruit is approximately one-half inch in diameter. The potato leaf hopper, although out of hibernation and feeding upon bean plants soon after these are out of the ground, does not go to potatoes until three or four weeks after they are above ground, although they normally appear before the bean plants. Some of the most detailed and observant work in America has been in connection with the life history and incidentally the location of the alternate food plant of certain of these insects.

Metamorphosis.

From a biologic point of view metamorphosis is a very important factor in the life of the insect and has given opportunity for remarkable variation in the biology throughout the groups, and complications in various stages of the life cycle of the individual.

The immature forms of insects with gradual and incomplete metamorphosis are usually well fitted for an environment in which they are capable of finding their own food and providing for their own protection. As a rule the environmental condition is only slightly changed in the adult stage, where the wings are used to advantage in carrying the insect to a little wider range of this condition, but not as a rule a new environment.

Insects with complete metamorphosis present a somewhat different picture and vary greatly in the larval condition. Many of them as found in the Coleoptera are not only able to seek their own food, but are provided with structures by which they can overcome other powerful insects. In the case of many Diptera, the eggs must be placed in connection with decomposing organic matter or the larvæ die. The insect larva in other cases, like certain Hymenoptera, becomes absolutely dependent upon the food supply stored in a cell with the egg and furnished in the form of pollen cakes or paralized insects and spiders. In the extreme case which we find in social insects, the larva must be cared for each day by insect nurses, which supply fresh food and other daily necessities. The dependence upon a food supply and upon other insects becomes greater and greater in specialized forms of complete metamorphosis, which fact is greatly significant biologically.

The great mass of biological data which has been obtained has shown us another significant fact. It is that as metamorphosis becomes more complete, the larval and adult stage become more diverse, not only in structure, as great as that may be, but also in habits and frequent adaptations to entirely different environments with different types of food and feeding habits. Illustrations might be taken from several groups to show this, but certainly typical examples are the predaceous syrphid fly larva and its flower feeding adult stage on the one hand and the hymenopterous larva feeding on paralized larvæ, aphids or spiders with its blossom feeding adult on the other hand.

Hypermetamorphosis shows still another condition where during the life of the individual larva it may pass through different forms and different environmental conditions.

Life Cycle Variations in Relation to Environment.

Biological studies have further revealed that there is the greatest of variation in life cycles among insects, even those in some cases which are very closely related. The stored products insects might be cited as examples of those which are probably most uniform in type of life cycle if considered in the light of their comparatively simple environmental factors. Plant factors and many similar conditions are eliminated almost entirely in biologic studies of these types of insects. On the

other hand, we find many complicated life histories which must fit into definite growing or fruiting periods of plant life or in limited periods of time. The food for the growth period may be available or in condition at only one or two short periods of time during the season, and if the larva cannot complete development within this time the species will not survive. This condition is found in the case of the oriental fruit moth on the peach tree. Here only the new tender twigs are favorable for establishment and if the fruit crop does not set the insect is forced to other food plants or starvation. Also the larva of the apple flea weevil must have tender foliage for its leaf mining stage, and the larval period is limited to the early season. It may be necessary that the egg be laid at a certain time or within a very limited period, especially if placed in plant tissue or a similar changing environment, since the ovipositor may not be able to penetrate such tissues after they have matured. Many of the Homoptera fall into this class and the life cycle will be determined largely by the availability of succulent tissue for feeding and oviposition. The termination of the growth period in any specific plant will determine the time of egg laying. Migration, pupation, ecdysis or some other life process or function may be restricted in the life cycle by a similar condition. Such factors usually determine the length and duration of the feeding stage, the number of generations within a limited time, the time of egg laying and other life processes.

Adaptations.

In connection with the life cycle, biological studies have shown remarkable adaptations of insects to almost every condition in nature. Striking adaptations for respiration, locomotion, feeding, protection and almost every other necessary function have been found in aquatic insects as well as most types of terrestrial life. In the case of insect eggs for instance we find some placed on stalks to prevent their destruction by active insects. When the egg is laid in water it is so constructed or placed that the egg will be supplied with both air and water, even when the water level changes. If the egg is placed in plant tissue, some provision occurs which prevents the pressure produced by the growing cells of the plant from crushing it. In order to insure the proper condition the plant stem or twig may be girdled or an incision cut in such a way that the growing tissue will expand into this opening thus preventing pressure on the egg until after it hatches; or growth may be inhibited in that portion of the plant where the egg is placed The plum curculio egg on fruit is placed in the tissue after this provision is made. The tree hopper places parenthesis-like incisions around the egg which prevent crushing while the twig girdlers provide not only this condition, but also assure the proper medium in which the larva may feed.

All work pertaining to the study of insect biology in relation to the formation of insect galls, the appearance of the two sexes normally developed in alternations with the parthenogenetic viviparous generations, or the development of winged and wingless generations occurring frequently in a single species and these alternating between different food plants have been outstanding contributions toward our conception

of the biologic complications and adaptations of insects and have incidentally furnished some of the most puzzling problems which we have attempted to solve.

Certain of our important insect pests are native and have gone from wild to cultivated types of plants. Biological studies of certain of these have been valuable contributions in showing us the relat'onship of the insect to native vegetation and how the insect has become adjusted to artificial cropping. The chinch bug is a good example, in which case the Andropogan grass of the prairie furnished the thatch roofed abode for hibernation. The distribution of the insect has corresponded in general with the distribution of these bunch grasses. It has thus survived and remained a pest since the two generation cycles fit perfectly into the wheat and corn cropping of this area. Many similar examples of economic species could be cited to show the same results with native insects.

HABIT.

One of the most interesting and important factors wh'ch has been revealed by biologic study is the place of what we might term "habit" in the life of the insect. We commonly speak of this as instinct in spite of the fact the psychologist has refused to recognize anything as instinctive. But certainly the hatching larva has neither knowledge nor conditioned reflex to guide it in performing a certain definite and specific type of behavior. The codling moth, for instance, upon hatching, will crawl to the calyx of the apple and many times will travel a considerable distance to find it. The oriental fruit moth will refuse to ingest the first portions of tissue taken from the surface of the fruit. Certain insects, like the Indian meal moth, will migrate long distances before pupation. We might go on to mention habits such as leaf-rolling, leaf tying and many cases where habit plays an extremely important role in the life of the insect. Numerous contributions of this type have been added to our knowledge of insect life by biological studies.

A knowledge and understanding of biology has been almost entirely lacking, however, in ecological survey problems. In these studies insects have been obtained from a wide variety of habitats and the investigator has attempted to associate each of these with a specific habitat condition. Frequently the writer has been asked to identify a large amount of this material in his special field. An attempt to do so revealed the fact that only a small percentage of the species which should have been obtained was found or observed in the field by the collector, and that those species collected were cosmopolitan and were known to exist under widely different habitat conditions in nature. As a consequence, such results have been of little or no value in view of the investigators lack of knowledge of insect biology and of insects and their habits in nature. The only valuable contributions of this kind have been made by those who are specialists on certain groups of insects which they have studied in the field and consequently are acquainted with biology and habits in these groups which exist in limited and specific associations.

Parasite Studies.

One of the most important and outstanding contributions which has been made, is the enormous amount of biologic and life history studies, completed or in progress, of parasites of economic insects. If we ever succeed in the establishment of a biologic balance in nature the parasites of insects will be a primary factor. The results that have been obtained have laid the basis for this work. Through these studies we have learned what we know about parasite and host relationships in such problems as host selection or preference, and alternation of hosts, hyperparasitism, superparasitism, polyembryony, comparative fecundity, paedagenesis, and many other parasite problems.

Some of the most striking and unique examples of adaptation to the life history of one or more species of insect host has been demonstrated by work in this field. The relative rate of reproduction and development as compared to the host under varied climatic conditions has demonstrated the limitations in certain of these biologic relationships as well as the opportunities for economic success. Several of these parasite life history studies have been so unusual and difficult, especially in regard to the tracing out of certain portions of the cycle, where the larva must find the host, that the solutions of these problems have been outstanding contributions to our knowledge in this field of work.

Biological studies in America of many types of Diptera and insects in other orders have demonstrated the probable origin of parasitism in these insects. If we cite the example of the screw-worm fly we find an insect which usually spends its entire feeding period on decomposing animal tissue of dead organisms. On the other hand, the female is frequently attracted to decomposing tissue in wounds of living animals for oviposition. From this point the insect takes up a parasitic habit in living tissue. This seems to be a transitional form between a scavenger on the one hand and a parasite on the other. It certainly is a real parasite in the making.

The Insect in its Relation to Other Organisms.

If we turn to look at the relationship of the insect to bacteria and protozoa, especially as these organisms cause disease in plants and animals, we find that biologic study has produced a vast array of contributions in this field.

Probably the most unique association which has thus far been demonstrated in the case of plants is the example of the cucumber beetle and its relationship to cucumber wilt. It has been demonstrated that the bacteria which cause cucumber wilt are commonly found in the alimentary tract of the cucumber beetle and can pass the winter in this way. The most amazing thing, however, is that the bacteria apparently do not live through the winter in any other form or manner and that the disease is dependent for its survival upon this insect which hibernates. In other investigations insects have been demonstrated to be important or sole transmitters of fire blight, mosaic diseases, curly top of beets and other organisms or viruses which cause diseases in plants. Other

diseases produced in plants chiefly by sucking insects are apparently caused by injecting toxins or other prevention of natural plant processes. Such conditions as hopperburn, alfalfa yellows, dwarfing and stunting are typical. Also growth in fruits may be inhibited in certain local areas by insect punctures or the injection of toxins.

A great variety of conditions are found when we study the relationship of the insect to protozoa, bacteria and other parasitic organisms in the case of man and other animals. Chief among these problems are a group in which the insect is the primary host of the protozoan and man or other animals are the secondary hosts. Malaria is a typical example. In such problems the protozoa cannot complete their sexual cycle except in the body of the insect which apparently is not seriously affected by the presence of the protozoan while the disease condition is produced in man.

In some cases the organism apparently has no definite relationship as a host, but merely passes through the body without affecting it and causes disease in man through fecal infection, especially in wounds. Trench fever is a good example of this type.

In other cases disease organisms are transmitted by the body and mouth parts of insects in view of their habits of feeding upon waste products of alimentation which contain these and soon afterward feeding upon man's food. Or soiled mouthparts may transmit from blood stream to blood stream.

In cases like the Texas cattle fever where the tick is the vector, biologic studies have shown a cytoplasmic transmission of the protozoan from mother to offspring. The young ticks upon hatching are then able to produce the disease in cattle.

Biological studies of insect parasites of man and animals have also shown many different types where the larva spends many weeks or months attached to the stomach wall, living upon digested food or embedded in muscle or other tissue. All the vital systems of the body as well as the external structures are attacked by various of these insect parasites. The biological studies have been noteworthy in this field, not only because of the contribution to our knowledge of the great array of biological complications in these insects, but also because of their relationships to these one-celled organisms and to the vertebrate hosts.

HEREDITY.

Incidentally, rapid and enormous progress has been made in heredity through biological studies of insects. The rapid rate of reproduction, the short time required for development to maturity, the ease of handling and rearing these on artificial media or under artificial conditions, and the consequent large numbers of both generations and individuals which can be produced in a comparatively short space of time have been important factors in the biology of the insect which has rendered it an excellent laboratory material for this phase of work. Through this medium many important facts concerning the transmission of inherited characters and the behavior of genes through varied matings have been obtained.

Significant data has been accumulated from insect biology upon such problems as sex chromosomes and their behavior, linkage and crossing over, sex linked inheritance and reverse mutation. From the same material important information has been gained concerning the diploid, triploid and tetraploid types of chromosomes and their significance. Also many additional curious facts or phenomena, such as, the lethal effects of homozygous conditions in many dominant mutants, have been found to occur in insects.

Although these data have not been gained directly by the entomologist, results have been obtained largely by insect biology work, the result of which has been a significant contribution especially since important laws have been formulated by means of these data, which laws are fundamental in all biology work with plants and animals and consequently are fundamental bases for our science and its future problems.

We might cite one instance to show how heredity has affected our present day problems. Biological studies have demonstrated very definitely that in a number of instances we have closely related insects which in nature behave differently biologically, but which are still designated by the same scientific and common name. So far as we know there are no morphologic structures which will distinguish these forms which differ biologically. Color patterns are identical; size, form and habits are the same, but we have two apparent biologic species. The two strains of European Corn Borer which have been introduced into America are apparently two such biologic species. They behave differently biologically under exactly the same atmospheric conditions and when the same food supply is present. The codling moth, the trichogramma parasite and many other insects exhibit the same condition. The taxonomist cannot be blamed for this condition, because he has not recognized these as separate forms up to the present time. We can place this responsibility, therefore, only upon the laws of heredity and variation. Numerous examples of this kind have definitely demonstrated that the factors of variation and selection are so closely associated with biologic work that we may expect to find biologic strains or races arising at any time.

These studies have also demonstrated that regardless of the environmental factors which surround the species, so long as we are working with living insects, we may expect to find the gene playing an important role in regard to variation or mutation and as a result natural selection. When we attempt to study or formulate the biology of any insect these phenomena must be taken into consideration.

CONTRIBUTIONS TO MORPHOLOGY OF INSECTS.*

William P. Hayes,
University of Illinois.

Morphology is fundamentally a descriptive science. Our descriptions by comparison with other species lead to ideas of relationships that take us into the theories of evolution. If we are concerned with the phylogenetic aspects while attempting to understand homologies, we are then browsing in the field of comparative anatomy. It is evident, then, that a knowledge of morphology is basic to a knowledge of function and physiology, and that a knowledge of phylogeny depends upon morphology as well as embryology and paleontology, both of which are studied mainly from the structural standpoint. As regards taxonomy, except for some feeble attempts to establish physiological and ecological species, its dependence on morphology for our systems of classification can be summed up in the recent statement of Ferris (1928) in which he writes, "the greater part of our work in systematic entomology must be based upon a study of external structures, that is, upon morphology. It follows that morphology and systematics are essentially synonymous and inseparable. A genuinely scientific system demands that every structure which is to be found upon the body of the insect be taken into consideration and until that has been done our work is to be regarded as incomplete."

Having briefly indicated some of the related fields to which morphology may contribute in advancing the study of insects in America, let us turn to a consideration of some of the important morphological works produced in America. We find, first, that the field is divided into gross and microscopic anatomy (histology). In spite of the fact that no logical or rational study of morphology can be accomplished without due consideration of insect histology, it is apparent that our contributions to insect histology are lagging far behind the advance being made in the study of gross structure. An exception may be made to the foregoing if we, as we should, give consideration to the progress made in insect cytology. Strangely enough, most of the work done in this field is carried on by zoologists and others not professing to be entomologists. By far the greater number of papers in this field deal with the subject of spermatogenesis. Notably among the contributions in this field are the works of Wilson (1905) in Hemiptera, McClung (1900–1908) in Orthoptera, and Hegner (1909) in Chrysomelid beetles. Most of our efforts in the study of spermatogenesis have been on individual species, such as the work of Charlton (1921) on the spermatogenesis of *Lepisma domestica*. Of greater importance are those papers involving comparative studies among which are the works of Boring

*Contribution No. 143 from the Department of Entomology of the University of Illinois.

(1907) involving twenty-two species of Membracidæ, Cicadellidæ, Cercopidæ and Fulgoridæ; Browne (1916), whose work deals with six species of Notonecta and Goldsmith's (1919) comparative study of spermatogenesis in Tiger beetles. Another type of cytological contribution is the study of the somatic cells, among which may be cited the works of Marshall (1907–1908) and Marshall and Vorheis (1906) dealing with the body cells of the walking stick and a species of Trichoptera. The recent papers of Ferris and Chamberlin, (1928), Campbell (1929) and Snodgrass (1929) bid fair to revolutionize our ideas of the structure of insect cuticula.

A greatly neglected field is that of insect pathology; little has been accomplished in this work, although we can cite the works of such writers as Glaser (1915) and others who in studying insect diseases are more concerned with the causal organisms than with the pathological results induced by invading disease. The general field of insect histology has been lightly sprinkled here and there with scattered works describing the microscopic features of various tissues and organs. Examples of American contributions of this nature are the widely quoted works of Hess (1917) on chordotonal organs, Glaser's (1912) study of oenocytes, and Muttkowski's (1923) recent paper on the structure and composition of insect blood. Jordon's histological studies of insect muscles in Mantidæ (1919) and Hymenoptera (1920) which are without doubt the best works of this nature that have been produced in America, and Riley's (1908) study of the muscle attachment of insects is frequently a matter of reference. The study of the nervous system, especially from its histological aspects, has been considered by Hilton (1917, *et al.*) and of increasingly greater importance to economic entomology are those works dealing with the sensilla of insects, notably among which are those of McIndoo (1914) treating with the olfactory sense.

Insect embryology has had comparatively few American morphological contributions. One of the earliest works on the development of insects before hatching is Packard's (1883)* paper on the embryological development of the locust in the third report of the United States Entomological Commission. Wheeler's (1889) works on Blatta and Doryphora (Leptinotarsa) are perhaps the most widely quoted, while our most extensive work is Nelson's (1915) treatise on the honey bee, which was followed by a detailed anatomical account of the larva, (1925). Recently Braur (1925) has issued a noteworthy paper on the four-spotted bean weevil (*Mylabris quadrimaculatus* Fab.) and Snodgrass (1926) has compiled in his "From an Egg to an Insect," a masterful and highly readable summary of our present knowledge of insect embryology. Polyembryonic development from its morphological aspect has been considered by but three American workers: Patterson's (1921) contributions to the development of *Paracopidosomopsis* parasitic on the Cabbage looper was followed shortly after by Leiby's (1922) paper on *Copidosoma*, a polyembryonic Encyrtid developing in the Golden-rod gall-maker. Leiby and Hill (1923 and 1925) have jointly considered the

*Minot (1878) reported preliminary embryological studies of the locust in the First Report of United States Entomological Commission.

development of two polyembryonic species parasitic on the Hessian fly. These are the sum total of our work of this nature in America and may all be considered as pioneering, fundamental studies.

Leaving at this point the discussion of contributions pertaining to histological and embryological morphology and turning to a consideration of studies on the gross anatomy of insects, it should be first pointed out, that in spite of the fact that there is scarcely a morphological fact but what has some practical application, American morphology has suffered from a dearth of adherents. Dr. Joseph Leidy may probably be considered our earliest American insect morphologist. In 1846 he published an anatomical study of the walking stick; this was followed in 1847 by two papers on Belostoma, one concerning the mechanism of the wings and the other on general anatomy. Recent workers devoting most of their efforts to morphological subjects can be counted on the fingers of one hand. In fact, but three American investigators stand out as pre-eminent morphologists, MacGillivray, Crampton and Snodgrass. MacGillivray is best known for his External Insect Anatomy (1923) his studies of wing venation of Tenthredinidæ (1906) and the contributions of his graduate students. His greatest work was his attempt to standardize morphological terminology and although he has added much to the confusion already existing by the proposal of many new terms and the naming of many minute, new structures, it has been the only serious attempt to straighten out the chaos which has arisen in the past. This effort has attempted to do for all insect terminology what the laudable work of Comstock and Needham (1898–1899) has done for the standardization of wing venation terminology. Furthermore, the works produced by his students have rarely been duplicated in America. Among these we find Peterson's (1916) work on the head capsule of Diptera, Stickney's (1923) head capsule of Coleoptera, Hoke's (1924) studies on the head and mouthparts of Plecoptera, Otanes' (1922) work of the same nature on the Mecoptera and Yuasa's (1920) treatise on the head of Orthoptera and Euplexoptera. The morphological studies of Fracker (1915) on the larvæ of Lepidoptera, Gage (1920) on larval Coccinellidæ and Yuasa (1922) in immature Tenthredinoidea were likewise done under MacGillivray's supervision. These are of special value in their taxonomic treatment of the immature stages of these orders.

Crampton's morphological papers are quoted in almost every modern morphological treatise. These, in most instances, are aiming at the broader aspects of phylogenetic relationships treated from the standpoint of comparative morphology. From his early works on the comparative morphology of thoracic sclerites (1909 *et al.*) down to his most recent works, Crampton has admirably striven to advance by comparative anatomical studies our knowledge of structural homologies. One of his works which I deem most important is his "Suggestions for the Standardization of Technical Terms in Entomology," (1915). The morphological works of Crampton's students are likewise mentionable as worthy morphological additions to our study of insects. Bromely's (1926) recent paper on the anatomy of *Tabanus atratus* Fab.

is an important anatomical study of this family of Diptera. Merrill's (1915) work on Pimpline Hymenoptera and Franklin's (1912–1913) monograph of the Bombidæ of the New World contain anatomical studies upon which the classification of these groups are based.

Johannsen and his students at Cornell have added to our whole by such contributions as that of Wu (1923) on the anatomy of Nemoura, a Stone-fly, Lloyd's (1921) North American Caddis-fly larvæ, and Buys' (1924) study of the adipose tissue of insects. Johannsen, himself, while primarily a taxonomic specialist in Diptera, has done some good morphological work, an example of which is his paper on the histology of the eyes of Drosophila (1924) and it is reported that he will soon publish an important embryological study of Lepidoptera.

Comstock's morphological treatise of insects in his early "Manual" (1916) and his more recent "Introduction" (1924) can not be overlooked because of their having an important bearing on the trend of anatomical study, nor can the laboratory guide of Comstock and Kellogg (1925), Elements of Insect Anatomy, be passed over lightly. There is scarcely a modern entomologist that does not owe his knowledge of insect structure to these works gained from classroom and subsequent use of these important source books.

Without doubt the foremost American morphologist is R. D. Snodgrass. For over a quarter of a century his entomological studies have been practically entirely devoted to insect structure. Not only is he a thorough student of anatomy, but an excellent artist and a pleasing and lucid writer. His early work on the anatomy of the Carolina locust (1892) is still much used, and his first bulletin on the Anatomy of the Honey bee (1910) has recently been converted into a much larger work on the Anatomy and Physiology of the Honey bee (1925). This is the most comprehensive anatomical work on a single insect done on this continent and will rank with such European classics as Straus Durckheim's (1828) work on the Cockchafer and Lyonnet's (1762) work on Cossus. We are soon to have published by him a general textbook on insect structure which if consistent with past performance should excel in its field. The works of Snodgrass cannot be passed over without mentioning his work on the Apple maggot (1924) which for its detail and illustrations is unsurpassed. His recent series of papers in the Smithsonian Reports are the most commendable morphological papers yet published. In these he has brought together a résumè of the present condition of our knowledge in the various fields which he has so far discussed. His "Morphology and Evolution of the Insect Head and its Appendages" (1928) is composed of more than 150 pages with an excellent bibliography and contains 57 illustrations. He has treated the subject of the insect thorax (1927) in a similar manner and those of us interested in this field look forward to a similar treatment of the abdominal structures. Two other summaries of a similar nature are his treatment of insect embryology and postembryonic development in his "From Egg to Insect" (1926) and his review of the all-important sensory structures of insects in a paper entitled "The Morphology of Insect Sense Organs and the Sensory Nervous System" (1926). Works

of this kind are of inestimable value in bringing together and reviewing from time to time the present status of our science. We can do no better in closing, than quote a statement from the last mentioned work of Snodgrass (p. 75) in which he says: "The last twenty-five years has seen a vast increase in our knowledge of insect structure in general, ... but by this very increase of printed information the work of assembling and reviewing can scarcely be done except by one who has all his time to devote to it. We must note with satisfaction, however, the increasing importance being given to morphology by the authors of our present general texts on entomology, and it is clear that the painstaking work of recent students will give to the subject of insect anatomy in the future a higher scientific standing than its adherents have heretofore been able justly to claim in its behalf." Finally, it should be pointed out that many good morphological works have been omitted from consideration herein because of the time limit of this symposium. The morphological papers herein considered may not all be American masterpieces, but each, in its own way, is an indication of the trend in the past toward the development of our knowledge of insect morphology.

CONTRIBUTIONS TO PHYSIOLOGY OF INSECTS.

EVERETT F. PHILLIPS,
Cornell University.

One who attempts at this time and place to evaluate America's contribution to our knowledge of the biochemistry and biophysics involved in insect dynamics is embarrassed by the fact that part of the 1926 and all of the 1927 symposia of the Society were devoted to similar discussions. The recent excellent summary on insect nutrition and metabolism by B. P. Uvarov also limits the desirability of references to specific papers. The greatest embarrassment comes from the vastness of the suggested subject. Under these circumstances it seems desirable to attempt merely a brief discussion of the place which physiology holds in American entomology. It may be said parenthetically that the physiology here discussed is not that based on guessed analogies or even on attempted homologies with functions in other phyla, which is the greatest source of inaccuracies in our assumed knowledge of insect dynamics. To the insect physiologist, an insect is something that happens, not merely an interesting bit of architecture on a pin.

Research of all countries gives us a vast store of information on the dynamics of insects, and it is immaterial where the work is done, except for the confusing Babel of tongues. That Americans have helped in this work is shown by a cursory survey of the literature, of which the

following are mere suggestions. In respiration, there are important papers by Lee, Welch, Cole, Clare, Bodine and Orr, Fink, Northrop, Muttkowski and Thorpe; in circulation problems by Gerould, Muttkowski, Haber, Bishop, Glaser, Hungerford, and Bodine; in blood sugars, by Blumenthal and Bishop; in nutrition and metabolism, by Swingle, Baumberger, Chapman, Abbott and Northrop; in the effect of colloid-bound water, by Robinson; in the effect of temperature on rates of activities, by Shapley and Crozier; in changes due to low temperatures, by Bodine and Payne; in chemistry of the entire organism, by McHargue, Davis and Rudolfs; in the physiological significance of symbionts, by Cleveland, Loeb and Northrop; in pH values, by Swingle and Crozier; in toxicity, by Campbell; in vitamins in relation to growth, by Richardson; in factors limiting length of life, by Pearl and Parker, Northrop and Glaser; in salt requirements, by Loeb. So the American list might be prolonged in every phase.

Uvarov cites 598 papers on insect nutrition and metabolism, not all strictly entomological, of which 15 percent are American and lists 425 authors of whom 14 percent are Americans. In his two symposium papers, Welch cited 59 authors of whom 35 are Americans and 77 papers of which 46 are of American origin, but from the nature of the occasions for these papers citations were restricted. It is absurd to ask or to intimate whether the American investigations are more or less extensive, or better or worse than those of other countries. Our only concern should be whether Americans are doing their share and whether we are doing what our own needs in entomological work would dictate.

Most of the physiological papers by American entomologists have come from institutions other than those in which agriculture forms the basis of the curriculum, and several universities where non-economic entomology is taught have produced excellent work in this field. Of the American papers cited by Welch in his two symposium papers, only a few eminate from agricultural colleges, and of those listed by Uvarov, less than half come from agricultural institutions.

Many of the most important American papers on insect physiology are written by men who make no claim to being entomologists and the average entomologist would not admit that they belong to the fraternity. A biochemist or physiologist, looking for suitable material for his research, goes to whatever branch of the animal or plant kingdoms will furnish him the most suitable species, and it is merely our good fortune if he selects an insect. Any discouragement of such work would be narrow and highly inadvisable, yet it is probably true that, other things being equal, such work would yield results of greater moment to entomology as a whole if done by those thoroughly familiar with other aspects of entomology.

While highly important contributions have been made by Americans in insect physiology, still American entomology has to a large degree ignored physiology, so that it is important to learn the cause or causes of this neglect. The chief impetus to the marvelous development of American entomology has been the necessity for control measures against important pests. In the first urgency, there is neither time nor

opportunity for physiological investigations, and for many pests the work is still admittedly in an elementary stage. Generally a second step is to find parasites, which work, while it is chiefly concerned with other biological relationships, implies physiology, but so far rarely includes it. The need for additional workers has also led many persons to engage in research work in economic entomology whose training and experience are such as not to enable them readily to do physiological work. There seems in this combination of circumstances to be a set of influences which have retarded physiological work on insects. It is a favorite pastime of those entomologists who dub their own work "pure" to decry the methods of economic entomologists, yet if it is remembered that much of this work is just beginning, and if it is recalled that some sort of control is immediately needed, another light is placed on the situation. It is only to be regretted that in many instances available methods of attack are not utilized, and physiology seems to be one of the most potent tools at the disposal of the economic worker.

Probably the worst indictment that can be brought against economic entomology is that workers in this field sometimes fail to appreciate the fact that the destruction of the insect does not always solve the problem which it presents. If the application of spray or dust materials results in the killing of pollinating insects in the orchard, if a dangerous arsenical residue remains on fruit which it is costly or impossible to remove, if it makes the already troublesome problem of marketing more difficult, if the application of a control measure upsets that vague but very real thing called the balance of nature to a degree which endangers the crop sought to be saved or some other crop, or if the control measure so seriously upsets social and economic conditions as to be more costly to mankind than the pest itself, the solution advocated is scarcely a success and is biologically or socially unsound. Such faults often arise from basing the efficacy of a control measure merely on counts of the number of insects killed or on the reduction in their numbers, and this is not sound economic entomology. The tremendously complex economic and social problems involved are too often lost to view in the belief that the most important thing is to kill the bug. In this connection it seems timely to condemn without reservation the promiscuous broadcasting of arsenicals over the countryside, not merely because it is a laughable example of the American way of doing things in a big way, but because it is biologically rotten to the core. Broadcasting happens not to be nature's way of balancing natural forces, and no biological problem can properly be attacked without at least mild adherence to natural law.

While economic entomology is dominant, those particular types of work so far undertaken tend to be self-perpetuating and this retards the efforts for new lines of attack. Where agriculture is the basis of the curriculum, the work in entomology offered, at least to undergraduates, must largely be that which fits the student as well as may be to attack the practical problems with which he will later be faced. It is natural and proper in such institutions that taxonomy, life history studies, some ecology and, most vital of all, practical control measures shall be

included. Morphology, physiology and the more complex and specialized phases of ecology and taxonomy are almost inevitably subordinated. This situation here sketched hastily and with corresponding inaccuracies at least gives a plausible excuse for the present neglect of physiology in agricultural institutions where the vast majority of graduate students in entomology are now found. There is the additional difficulty of the type and amount of training considered necessary for physiological work, which will be mentioned later.

Three agricultural institutions which are strong in entomology now offer courses in insect physiology and one other has definite plans for the inauguration of this work next year. In still another institution where physiology is acutely appreciated, advanced students in entomology are regularly sent to another department for training and guidance in physiological research. Most agricultural institutions, even some where entomology is strong, have failed to do anything in this field, and it is of course obvious that more entomologists are now trained as both undergraduates and graduate students in agricultural institutions than elsewhere. In practically all cases the inclusion of physiology in the entomological work is relatively new, but rapid advance is being made in some institutions and more and better work is planned and promised for the immediate future.

Modern physiological work requires extensive training and experience. Since the entering graduate student, especially if he comes from an agricultural college as most of them do, has rarely had courses as an undergraduate which fit him to undertake such work, considerable time is usually considered necessary to take special courses which might lead to physiological research. If these courses are so arranged that they may be cleared off quickly by intensive effort, the delay is not serious, but in many institutions where these courses are entirely or largely independent of the entomological work and where they are offered primarily for students in other fields, they are often arranged as courses to be taken in series, so that the requisite time of preparation becomes an eliminating factor. On the other hand, many graduate students in entomology are unquestionably required to take too many courses in entomological subjects to allow them time for suitable preparation for physiological work in insects. This is apparently an outstanding weakness in graduate work in entomology in several institutions. A teacher of graduate students can fill their time with required courses, apparently sometimes to keep them busy or to impress them with the immensity and complexity of his field, and a student can with the least labor and mental effort get some information regarding a special line of work by taking a course in it. A good teacher and a good student form a combination which should be able to reduce course work to a low limit. The academic tradition that graduate work requires three years does not of course fit into a graduate student's schedule where many courses are required or taken, if experience in research is expected. It is of course just as possible to require too much preliminary training in physiology as in any other phase of entomology, and this happens to be a fault often encountered.

This situation raises the question whether insect physiology should be included in the program of the department of entomology or whether it is as well or better to leave this work to other biological departments, such as Biochemistry or Physiology. The necessary administrative division of a college staff into departments often retards rather than promotes scientific progress and one of the greatest needs in academic work is to eliminate the petty jealousies and handicaps arising from the apparently necessary departmental organization, through a realization that science does not conform to the classifications of academic departments. Most entomologists who are interested in physiology seem to feel that it is best for work in insect physiology to be done in the department of entomology. One suspects that part of this feeling is based on departmental jealousies, although part of it is definitely due to experience in finding that co-operation with other departments, while fine in theory, does not work. We might well leave to biochemists such highly technical problems in chemistry as they may wish to undertake, but for the training of entomologists who are at the same time physiologists, it is essential under present academic organization that the student be trained in a department where insects are understood. Whether in theory this should be changed is rather immaterial, since we are confronted with a real condition in the present failure of academic departments to co-operate as they should. Almost every institution has such academic barriers to cross before insect physiology can be put on a sound basis.

There are, of course, myriads of questions constantly arising in economic entomology on which physiological investigations would be interesting. Is it possible or probable that a physiological attack on economic entomology would be actually helpful? For lack of experience, there is here still room for some difference of opinion. There is, however, real reason to believe that such an attack would be more helpful in some cases than the types of work now common. A recent paper by Cotton and Young shows that the action of certain gases on respiratory processes may be made applicable to insect control. A knowledge of the rate of increment of various activities, especially on the rate of development, has already been used to some extent and has been speculated upon still more, and it is necessary only to mention the work of Headlee, Sanderson and Peairs to show that modification of rate of development due to temperature is economically important. One difficulty in the work of the effect of temperature has been a failure to appreciate, or at any rate to weigh, the obvious fact that temperatures at one or two times of the day are of little value, for temperature is a constantly working and ever changing factor, speeding up or retarding development every second of the day. So-called accumulated temperature fails to take into consideration the extreme rapidity with which a change in temperature changes these rates. The non-economic investigations of Crozier and Shapley have great significance here. They are beyond doubt, as Uvarov states, many cases in which a knowledge of metabolism will be necessary to proper control. I cannot at the moment think of any cases where a knowledge of circulation problems

might be applied, yet this is not impossible. Several papers have appeared on the effect of insecticides on insects, this being a highly practical consideration. The chief difficulty in this problem seems to be that so little is known of physiological processes that it is difficult or impossible properly to interpret the finding in the highly specialized problem. This work seems somewhat premature, which is said with no thought of criticism of those who have tried to solve it.

The discovery that the European corn borer and Mexican bean beetle are restricted in their serious occurrence to areas adapted to certain soil types is of itself important, but this astonishing and hopeful findiing, instead of being wholly satisfying, at once causes one to wish to learn how this is true. Is there a physical or chemical difference in the plants grown on different soils? If such a difference exists, in what manner does it affect the insects? Such physiological differences have been claimed in the case of resistance to Phylloxera of American vines and in the comparative immunity to woolly aphis of certain fruit varieties, which suggests that it is high time to transfer the corn borer and Mexican bean beetle problems away from ecology into physiology and some recent work at the Wooster Station looks as if this were being done. Naturally such work might throw light on the distribution of many economic species, for frequently the place to study an important pest is where it does not exist.

The apparent limiting effect of hydrogen-ion concentration on mosquito development, or perhaps it is the presence or absence of some salt or acid, the specialization of insects to certain host plants, or their occasional failure to stick to what was once their host plant, the proposed inner therapy for the control of sucking insects, these all are within the realm of physiology and should be attacked from that point of view alone.

The moral of this tale seems rather obvious. Physiology as a tool should be used more widely for the solution of economic problems and more work in this phase of entomology would strengthen other phases of the work. Aside from a readily remedied shortage of teachers, the present lack of work in insect physiology in many institutions appears to be due more to difficulties of academic organization than to any other single cause, and it rests with the entomologists to point the way in the solution of these puzzles. Naturally one cannot expect a biochemist or physiologist to concern himself in finding the deficiencies in entomology as now presented and as used as a tool for research. The problem of enlisting physiology as a means of solving some of our troubles is being attacked in a few places and should be given serious attention in other institutions. Every advance in this phase of the work puts entomology in a stronger position with other branches of biology and it is scarcely necessary to suggest that such a strengthening is desirable and would be welcomed. It would be foolish to suggest any universal method for the solution of the academic difficulties outlined, for each institution has peculiar internal influences which must be considered. It is not the purpose of this outline to give a full solution, but rather to indicate the reasons for the present neglect of physiology

in entomology, as well as to suggest the vital necessity of finding means to strengthen it.

About the most unwise undertaking on which one may embark regarding scientific work is prophecy. Yet viewing the progress already made and sensing the possibilities for further applicable knowledge, one is led to hazard a guess that within another decade or so, additional insect physiology will be recognized not only as essential from a purely scientific standpoint, but eminently useful and virtually essential in many economic aspects of the work. It will be difficult for all entomologists to enlist in the army of physiological workers, but those who remain outside may be left at the rear of the procession of progress. If there were any reason to look on a study of insect dynamics as merely another scientific fad, one could advise that it be scorned, but it is no fad to learn how insects live.

In order to promote this work, certain changes in our personal points of view regarding physiology seem desirable. For those not yet engaged in such work it is important to get away from some fear of the technique which apparently exists. The fact that one has reached the age of thirty or more, or that his formal academic training is past is no excuse for avoiding this field. In academic training there must be a clearer recognition of the fundamental value of physiology and it must be included in the training of graduate students, even though it necessitates the elimination of courses which are now considered necessary. Physiology is not the first phase of entomology to be undertaken, but it is certainly one of the most vital.

Apologies are due the Society for so great a departure from the subject assigned. Further apologies may be considered desirable because of the emphasis which has been placed on the lack of physiological research in economic entomology, yet when one considers the necessary emphasis on economic phases of the work under American conditions, it seems to be a true picture of American entomology to stress this part of the work. It would have been a pleasure to use the time allotted to point out noteworthy things that Americans have accomplished in insect physiology, and even an easier task. One could almost make the eagle scream in this way. We Americans are accused of being too prone to advertise our virtues, so perhaps it is permissible to try to suggest reasons for one of our lacks. It is at any rate more in keeping with our desires to do this ourselves rather than to have it done by others.

The situation, while here painted somewhat discouragingly is still one of real hope. There is evidence of progress in agricultural institutions along lines of a study of insect dynamics and several institutions are now making plans either to introduce or to increase their work in this line. We can at least express the hope that their progress will be rapid.

CONTRIBUTIONS TO ECOLOGY OF INSECTS.

SAMUEL A. GRAHAM,
University of Michigan.

Insect ecology is a mere infant as compared with the other subdivisions of entomology and it would seem therefore that the discussion of the important contributions of America in this field would be a relatively simple undertaking. But after the present effort it appears clear to at least one individual that such is not the case.

It has been only sixty years since Haeckel proposed the name and defined the scope of ecology and only a little more than twenty years since the importance of this field has been even slightly recognized by entomologists. Not until very recently has ecology come to occupy an important place in the eyes of the entomological profession as a whole. It is doubtful if as recently as ten years ago the subject ecology would have been included at all in such a symposium as this. Today insect ecology is accepted as a well defined and important division of entomology. So thoroughly has it been accepted that some of us can scarcely realize that it was not always thus.

Exactly twenty-one years ago today, December 28, 1908, at the annual meeting of the American Association for the Advancement of Science in Baltimore, Dr. Forbes in his presidential address before the Association of Economic Entomologists made a prophecy. He expressed the opinion that ecology, together with the application of biometric methods, would play a prominent part in the future development of economic entomology. His remarks on the economic application of ecology received little attention and passed unmentioned in the discussion which followed, despite the fact that at least two of those who took part in the discussion, Sanderson and Hopkins, later were to make notable contributions to insect ecology.

At that time entomological papers of an ecological nature were just beginning to make their appearance, although they were frequently unrecognized as ecological even by their authors. During the two years 1908 and 1909 six papers that might be regarded as ecological in character appeared in the *Journal of Economic Entomology*, then, doubtless, the most likely place in which to look for such material. These comprised only about 4 per cent of the total number of articles that appeared in the above mentioned volumes.

Compare this with the number of ecological articles published in the same journal during the last two years. During 1928 and 1929 the *Journal of Economic Entomology* published forty-eight articles of an ecological nature which comprised approximately 15 per cent of the total number of articles published, a very considerable increase especially when we consider that a number of other periodicals are now printing papers on insect ecology. In addition to this increase in ecological papers, a distinct ecological trend may be observed in many works

dealing with biology and control. For instance, the recent publications on the codling moth, the corn borer, the Japanese beetle, and the Mexican bean beetle show distinctly the influence of an ecological approach.

At the time of Forbes' prophecy the influence of environment was seldom considered in biological studies. Insects were reared and the stages described without attempting either to control or measure even the most obvious physical factors, like temperature and moisture. We learn from these biological studies that the period of incubation for the eggs of a certain insect is so many days, that the larval period is so and so, that the insect remains in the pupal stage just so long before emerging as an adult, but seldom are we told under what conditions these facts are true. It was not at all unusual for entomologists, especially the inexperienced, to calculate on the basis of such laboratory observations the number of generations through which an insect species might be expected to pass during a season under natural outdoor conditions, without realizing that environmental factors inside and outside the laboratory were very different.

Today such inaccuracies as those just mentioned are rarely found in entomological literature. Almost without exception some effort is made to evaluate the influence of environmental factors and often the facts observed are interpreted in terms of these factors. Undoubtedly Dr. Forbes' prophecy of twenty-one years ago is coming to pass and the ecological approach to entomological problems, especially in the economic phases of entomology, is becoming more and more important.

But economic entomology is not the only field in which ecology is finding a useful place. The influence of environmental factors, like food, moisture and temperature, are being considered more and more in taxonomic investigations. The morphologist, the parasitologist, the physiologist, likewise appear to be concerned more and more with both physical and biotic environmental influences.

From this brief review of the entomological situation as it exists today we must conclude that ecology, or at least the ecological attitude toward entomological problems, has doubtless come to exert a marked influence upon the study of insects. But what are the chief contributions in America that have brought about this condition and have led us to regard insect species as a part of, and to a certain degree the result of, the environment in which they live, rather than more or less unrelated entities?

This is not so simple a question as it may appear to be at first glance. Perhaps it cannot be answered at all at present. Numerous important papers come to mind, but with them come others of apparently equal value. Can we say that any single contribution or group of contributions lies behind the rather phenomenal growth of the ecological concept in entomology? Is not this development the result of a gradual realization, growing in the minds of numerous workers at the same time, that the conception of each animal as an entity in itself is inadequate, and that the consideration of animals as part of the environmental complex is necessary to the satisfactory interpretation of existing facts?

If this is true, then we cannot expect to find in literature the cause of ecological development in the study of insects. The published facts are the results of this development rather than the cause. But even though the underlying cause of ecological development must be looked for elsewhere, certain published works have wielded a greater influence than others in guiding the trend of ecological development.

One of the first that comes to mind is Chapman's book, "Animal Ecology with Special Reference to Insects." This work is of especial value for two reasons. First, it brings together under one cover a great mass of material which is widely scattered and often inaccessible to the average worker, and secondly, it organizes and clarifies our ecological concepts. In this book Chapman has formulated laws and principles that apply not only to insects, but to all other life as well, and by so doing has gone far to show the unity in the multitude.

For instance, his conception of the powers of multiplication possessed by insects and the effect of environmental factors as being measurable forces has done much to make real that formerly ephemeral phenomenon, biotic balance. The idea that various elements are, under normal conditions, so arranged that their combined effects bring about a relatively constant condition is so old that it is scarcely safe to hazard a guess as to its time of origin, but Chapman in the book referred to above, and in other writings, has conceived of the ability of insects to reproduce as being a measurable positive force against which are acting forces of the environment.

The force of reproduction he calls *Biotic potential* and the forces of the environment he calls *Environmental resistance.* These forces he compares with the potential of an electric current and the resistance of the wire over which the current passes. Biotic potential is defined as the inherent power of an organism to reproduce itself in a given time in the absence of environmental resistance. Environmental resistance is defined as that force or combination of forces which reduces the potential rate of multiplication. The biotic potential is constant for each species and can be determined by experiment. The number of individuals in any environment can be determined, and a comparison of the number of individuals actually present with the potential number that would be present in the absence of environmental resistance affords a quantitative measure of environmental resistance.

Obviously although the numbers of an insect population may vary somewhat from time to time, there must be in general a condition of relative equilibrium between the forces of Biotic potential and Environmental resistance. If this were not true, the species which encountered a degree of environmental resistance too low in relation to their biotic potential would ultimately come to dominate their environment, while those meeting excessive resistance would ultimately become extinct. This hypothesis of measurable positive and negative forces which result in a condition of relative equilibrium does much to make concrete our previously hazy conception of biotic balance. Furthermore, the demonstration by controlled experiment that at least certain factors of environmental resistance can be segregated and measured quan-

titatively has already gone far toward establishing Chapman's hypothesis as a fundamental law of ecology.

Other important fundamental hypotheses have been formulated as a result of entomological research in America. One of these is the Bioclimatic Law of Hopkins. Although it has not escaped criticism because of certain obvious weaknesses, this empirical law has demonstrated its practical worth especially in connection with protection of winter wheat from the Hessian fly. When the date of any periodical event is known in one locality, other things being equal, the date of the same event in another locality may be calculated by the application of this law.

The law may be stated as follows: Other conditions being equal, the variation in time of any periodical event in temperate North America occurring in the spring or early summer is at the general rate of 4 days later to each degree of latitude northward, or 5 degrees of longitude eastward, or 400 feet of altitude upward. In late summer and fall conditions are reversed. Like most empirical laws it is likely that further research may result in its modification, but even with its present imperfections it is undoubtedly one of the outstanding contributions of America to insect ecology.

Another fundamental ecological hypothesis which has not received the attention it deserves is the "Host Selection Principle." This hypothesis was originally formulated by Hopkins and was later demonstrated experimentally by Craighead and others. It may be stated briefly as follows: The progeny of any insect species that normally feeds on two or more hosts tends to breed on the host on which it was reared.

Craighead has demonstrated that certain wood-boring insects not only prefer that host on which they were reared, but are not as successful in developing, surviving, and reproducing themselves when transferred to another host. But he has also shown that when forced to continue breeding on the second host the survivors produce progeny which have a preference for that host. (Is this a demonstration of the inheritance of an acquired character?)

America has made noteworthy contributions toward the better understanding of insect distribution. Cook's theory of Bioclimatic Zonation provides us with a concept of the economic distribution of insect species that is very valuable. He distinguishes within the zone of taxonomic distribution of an economically important insect four distinct zones:

1. The zone of normal outbreak, in which the insect is adjusted to the normal climatic conditions and is controlled by weather variations, but primarily by biotic factors.

2. The zone of occasional abundance, adjacent to the normal zone, in which the insect is not adapted to the normal climate, but to variations from the normal. Here it will be controlled by normal climatic conditions and to some degree by biotic factors.

3. The zone of possible abundance, still farther removed from the normal zone, in which a permanent population is not maintained,

but outbreaks may result from migrations from the inner zones when favorable variations from the normal climate occur. Here climate is the most important agency of control, although biotic factors of a non-specific nature may doubtless play a part.

4. The zone of possible occurrence, where the insect may occasionally be found, but never in injurious numbers.

Cook's application of the hythergraph to indicate this bioclimatic zonation is an important application in America of a method developed elsewhere.

American entomologists have contributed much to the knowledge of the effects of physical environmental factors on the rate of insect development. Sanderson and Piers, working with the influence of temperature upon the rate of insect development, were the first to establish the fact that within certain limits the time temperature curve of development of any stage of an insect is a segment of an hyperbola, the reciprocal of which is a straight line. This work antedates the better known work of Krogh by some months.

Numerous workers have studied the effect of moisture upon insect development. Notable among these are the well-known experiments of Headlee. The study of the combined effect of temperature and humidity has been made by Pierce, Shelford and others. Pierce developed a method of graphing the combined effect of these factors in a series of concentric zones which has been widely adopted by other workers in various fields. Shelford's contributions to our knowledge of the relation of weather and the coddling moth are classics.

American workers have made noteworthy contributions to our knowledge of the nutritional factors. They have demonstrated that the food of insects is not always what it appears to be. For instance, Baumberger has shown that Drosophila is unable to develop to maturity when microorganisms such as yeasts are absent from their food. It has been shown by Cleveland, Kofoid and other workers that some insects, as well as other animals, which eat wood have within their digestive tract symbiotic microorganisms upon which these animals are dependent for the digestion of cellulose. When deprived of these microorganisms Termites are unable to obtain nourishment from the wood they eat. Chapman has reared Tribolium upon a synthetic medium, but later the possible presence of intestinal microorganisms was indicated. We might go on and mention numerous other contributions of American entomologists in the field of insect ecology, especially studies leading toward the solution of pressing economic problems, notably Huber, Neiswander, and Salters' investigations concerning the European corn-borer and its environment, Carter's work with the beet leaf-hopper, and the studies of Dendroctonus beetles by Craighead and his co-workers in the Bureau of Entomology. Forest entomology is rapidly becoming almost exclusively applied ecology. If we can judge from the amount of ecological work now under way it seems safe to say that the production in the field of insect ecology will be greatly increased in the near future.

After the foregoing consideration of insect ecology, although time limitations have made it necessary to omit much of importance, it

seems evident that America is well represented by contributions in this field. But the development has just begun. Insect ecology is today in a condition comparable to chemistry or physics one hundred years ago. It is still in the fact-gathering stage. The application of quantitative analysis must be carried farther than it has been so far. Biological constants similar to the constants of physics and chemistry must be determined. Facts and still more facts must be accumulated to provide the basis for the formulation of more ecological hypotheses. These hypotheses must be tested in the heartless crucible of controlled experimentation to separate the pure metal from the dross. And finally, all these facts, laws, and principles must be brought together to form a comprehensive whole which will probably make our ecological efforts of today appear feeble indeed.

CONTRIBUTIONS TO APPLIED ENTOMOLOGY.

ARTHUR GIBSON,
Dominion Entomologist, Ottawa, Canada.

Since the year 1841, when the State of Massachusetts published the classic volume prepared by Thaddeus W. Harris, economic entomology in North America has made remarkable progress.

Much of the early work was concerned with poisons for the destruction of insect pests. Since the use of Paris green, between the years 1860–1867, as a poison to destroy the Colorado Potato Beetle, there have been many contributions to the subject of insecticides. Up till about 1892, Paris green was practically the only stomach poison used. Since then such materials as arsenate of lead, arsenate of lime, white arsenic, sulphur compounds, oils, oil emulsions, the fluosilicates, as well as others, have been produced extensively in North America and used over a very wide range of territory. The insecticide industry has thus developed to the value of hundreds of thousands of dollars, giving employment to many workers, including trained chemists and entomologists. Machinery, too, for applying insecticides has developed from the first spray gun available in 1896 to the various types of high power sprayers and dusters now used in gas driven machines. Even since 1921, the year the airplane was first used in America to distribute poison, there have been many improvements in this method of application.

Coquillett, in 1885, reported success in controlling grasshoppers in California with a mixture composed of arsenic, sugar, middlings and water. In the same year, as he also reported, bran was substituted for middlings, and has since been adopted generally as the carrier for the poison. In 1901, the Criddle mixture was evolved in Manitoba and has since been used extensively in many parts of the world. Two years later Criddle conducted experiments in Manitoba with a bait composed

of equal parts of bran and sawdust, with salt and arsenic. Later, in 1915, sawdust was used over a wide area in Ontario and Quebec. In 1914, Dean reported the adoption of a bait in which oranges or lemons were used and which became known as the Kansas formula.

From a summary of expenditures and results of grasshopper campaigns conducted in the United States and Canada from 1913 to 1923, prepared by Dean, it is of interest to note that over 105,000 tons of poisoned bait, costing $3,376,639, were used, as a result of which the estimated saving, or the value of the crops protected, was $143,692,975.

During the past 70 years many foreign insect pests of great economic importance have found their way to America, necessitating the appropriation of large sums of money for their study and control. The gypsy moth was introduced into Massachusetts in 1868 and in 1924 was found in Quebec. The San Jose scale reached California apparently in the early seventies, appeared in destructive numbers in the Eastern States in 1893, and in Ontario in 1897. The brown tail moth was discovered in Massachusetts about 1890 and in New Brunswick in 1902. The Japanese beetle was introduced into New Jersey in 1916. The European corn borer was found in Massachusetts in 1917 and in Ontario in 1920, and the Mediterranean fruit fly in Florida in April, 1929. These introductions, as well as others which need not be mentioned, demanded the establishment of fighting organizations such as no other countries have had to incept.

In the development of these large-scale control projects important progress has been made in devising better insecticides, as also new or improved machinery for applying the same. Implements for the destruction of infested plant material have also been invented. The introduction and colonization of promising insect parasites and predators has been incepted and is being continued under close observation.

In connection with insects found in dwellings, mills and warehouses, important contributions have been made during the last decade or so, not only following discoveries leading to the development of new preparations for purposes of fumigation, but, also, as a result of demonstrations proving the value of high temperatures, particularly for insects which affect flour, grain, and other products present in mills.

Up to 1921, efforts in North America to control injurious insects were directed from the ground. In that year the first experiment in using the airplane to distribute poisoned dust for the destruction of the catalpa sphinx was undertaken by Houser in Ohio, and this was followed by further tests in the same state in 1922. In this latter year, Burgess conducted experiments against the gipsy moth in Massachusetts, and Coad initiated experiments against the cotton boll weevil in Louisiana, and the method for the latter insect has since been commercialized. Following these demonstrations, much further experimentation has been conducted, in Wisconsin, by Fracker and Granovsky, for the control of the hemlock looper, and in Canada, against the spruce budworm in Nova Scotia and Ontario, and the hemlock looper in British Columbia, Ontario and Quebec. The work conducted in Canada against the latter insect, in 1929, gave from 90 to 100 per cent control.

The value of farm practices in reducing insect abundance is advocated generally by most entomologists. The importance of ploughing under refuse and the adoption of other clean-up measures as controls for the European corn borer have been demonstrated in recent years, especially in Ontario.

As a result of three years investigation in Ontario, Ross and Hall stated in 1924* that fundamentally the control of the rose chafer is a matter of farm management, that the plough, disk and cultivator are the most important weapons in fighting the insect.

In connection with grasshopper outbreaks in the range country of British Columbia, Treherne and Buckell reported in 1924† the importance of re-establishing the range grasses by judicious grazing at selected periods within a year, or on a definite rotation plan.

In Manitoba, Criddle and Mitchener found that the larvæ of the wheat-stem sawfly do not cut the stems of wheat until the plants begin to lose their sap. Early harvesting as a result of this important discovery, has saved crops worth millions of dollars. In Alberta, Seamans has shown (1928)‡ that permanent trap crops of brome grass, attract the females of the sawfly for purposes of oviposition resulting not only in the protection of adjacent fields of wheat, but also in yielding paying crops of hay or seed, and furthermore in assisting to control weed development.

In forest entomology, the investigations of Hopkins in the control of destructive bark beetles started in Maine in 1901 and in the year following in the southern and western states, has been of decided importance. The work has been further developed up to the present time, with marked progress by officials of the United States Bureau of Entomology. In 1913, Swaine incepted a study of the biology and control of bark beetles in the yellow pine forests of British Columbia. This resulted in the winter of 1918–1919 of the adoption of control operations on an extensive scale, namely, the cutting and burning of beetle-infested trees, the burning of all logging slash and the utilization of wind falls before the emergence of the beetles present in the bark. This control work has given definite and most satisfactory results, and is undoubtedly an outstanding example.

There can be no doubt that the impetus given to the study of ecology, as a branch of entomology, constitutes the most remarkable advance made in recent years. Under the leadership of such men as Forbes, Shelford and Chapman, there is gradually developing a school of entomologists who will attack the problems of the future from a new standpoint and with new methods, the possibilities of which appear to be well-nigh inexhaustible. An event of primary importance in this connection was the foundation of the Ecological Society of America in 1916, and the publication of its journal, *Ecology*, in 1920.

It would be impossible to give an adequate account of the excellent work that has been accomplished in the last few years by the investi-

*Rep. Ent. Soc., Ont., 1924.
†Ent. Br. (Canada) Circ. 25.
‡Rep. Ent. Soc., Ont., 1928.

gators engaged in this type of research. Suffice it to touch briefly on one of its most important phases, namely, climatology. The importance of climatic conditions in their relation to insect development and insect abundance has been recognized in a general way for many decades. Notes of a general character are abundant in entomological literature, but exact observations based on a systematic study of the subject are rare. So far as North America is concerned, Hopkins in formulating his famous bioclimatic law, introduced into agricultural practice and into entomology, a principle and a working theory which, although not perfect, undoubtedly constitutes one of the most brilliant contributions to applied entomology. The work of Cook on the distribution of the pale western cutworm and the alfalfa weevil constitutes another distinct advance in the interpretation of climatic influences upon the significance of insect outbreaks.

Shelford's study of the relation of weather to the abundance of the codling moth in Illinois is a remarkable contribution combining, as it does, all the best known methods in both laboratory and field observations. In Canada, we have the significant work of Seamans in Alberta, on the relation of rainfall in May and June to the abundance of the pale western cutworm and a dry July followed by a wet autumn to that of the army cutworm; also, the excellent study of King and Atkinson, in Saskatchewan, on the relation of disease, parasites and weather, to the red-backed cutworm.

Much progress has been made in assembling data regarding insect pests since the establishment of Insect Pest Surveys, in the United States in 1921 and in Canada in 1922. The monthly summaries of insect conditions published in both countries have undoubtedly served a very useful purpose. Hyslop has said,* "The data obtained as a result of insect pest surveys should be of far reaching value in connection with entomological forecasting."

Extension entomology, so-called in America, has made rapid progress particularly during the last decade. This progress is a direct result of the many contributions made available through research. The various spray service and other extension programs which have been developed with the assistance of the telegram and the radio, have aided very considerably in the production of better marketable crops.

Dr. R. J. Tillyard, in referring to entomological work in North America, said in an address before the Royal Society of Arts, London, England, October, 1926, "If you go into a shop today and compare the American or Canadian apples, now on sale, practically perfect in their shape, color, flavour and aroma, with the wretched products of some old, unsprayed insect and fungous-ridden orchards in this country, you will understand what economic entomology has done for fruit-producing areas. Costly as it is, it is the spraying program which makes it possible for America and the Dominions to send to Europe these perfect fruits, and without it there would be no possibility of finding a market for their products."

*U. S. Dept. Agric., Bull. 1103.

It would be interesting if we had the time to trace the history of insect legislation in North America from 1877, when the states of Missouri, Kansas, Minnesota and Nebraska, enacted laws for the destruction of grasshoppers. Two acts only will be mentioned here, namely, the Destructive Insect and Pest Act passed in Canada in 1910, and the Plant Quarantine Act passed in the United States in 1912. Many regulations have been issued or rescinded since the passage of the former act, but the act itself has never been modified. The Plant Quarantine Act of 1912 has been amended five times.

With regard to the biological control of insects, we are all familiar with the success which followed the introduction of *Vedalia cardinalis* Muls. from Australia into California to control the cottony cushion scale. Since that time, but particularly during the last two decades, the subject of biological control has received considerable support. In California, too, the commercial development of *Cryptolaemus montrouzieri* Muls. is an outstanding achievement. According to Smith* since 1918, this method of biological control for mealy bugs is practically the only one in use at the present time. In the same state, also, the native convergent ladybird beetle has been gathered in large numbers and later distributed in areas where plant lice were abundant.

Just recently we received Technical Bulletin No. 86, "Imported Insect Enemies of the Gipsy and the Brown-tail Moth," by Burgess and Crossman. In this valuable contribution it is stated that over 93,000,000 insect enemies were liberated. Two sentences are worthy of repetition here, (1) "The results thus far accomplished by utilizing parasites against the gipsy moth have been extremely beneficial and have saved the forests of New England from destruction," and (2) "The result of 24 years of work has demonstrated the great value of this experiment in parasite introduction—the most intensive and extensive that has ever been tried."

The introduction into Canada from England of the larch sawfly parasite, *Mesoleius tenthredinis* Morley, by Hewitt in 1913, was an important contribution. The parasite is well established in Manitoba, where it has completely checked its host. Resulting from liberations of material reared at the Dominion Parasite Laboratory, the parasite has also been recovered in Ontario.

With the discovery of the European corn borer and the Japanese beetle in America, the desirability of introducing and establishing their native insect enemies has received much attention. Millions of parasites of these pests have been reared and liberated at strategic points. With the continued support which is being given to these projects, we may assume that important progress is being made. Reference could be made to other parasite projects, but those mentioned are sufficient to show that important contributions to this method of control have taken place in North America.

Regarding medical entomology, the results of the brilliant investigations of Finlay, Reed, and others, in connection with *Aedes aegypti* L. as a carrier of yellow fever made it possible to eliminate this dread disease

*Jour. Econ. Ent., 18, 147.

from southern sections of the United States, where before the end of the 19th century, severe outbreaks occurred periodically, resulting in heavy loss of life. During recent years no one in North America has been more active than has Dr. Howard, in adding to our knowledge of the relationship of the housefly and other species, to typhoid and other diseases, as also in encouraging the inception of problems of great importance, not only as they affect humans, but also as certain of them affect live stock.

The discovery by Ricketts that the common wood tick is a carrier to man of the Rocky Mountain spotted fever, is also significant. Further admirable tick work has been conducted by Parker and others. The state of New Jersey, through its Mosquito Extermination Association, has made remarkable progress in reducing the mosquito population within the state.

In a very limited discussion such as the present, it has only been possible to refer, and this briefly and generally, to certain contributions, which in the opinion of the writer seemed outstanding. Had time permitted we might have referred to other contributions possibly equally important. No mention has been made of publications as such. What a quantity have been written by American students! Some of these were discussed by Lochhead in the Report of the Quebec Society for the Protection of Plants for 1916–1917 under the title, "Masterpieces of American Economic Entomology."

One reason, I think, why applied entomology in America has made such rapid progress during recent years is the fact that there has developed among our workers a very fine type of personality. The bond of sympathy which has increased so noticeably has been largely responsible for the bringing about of a co-operation, not only of state and provincial importance, but also of national and even international value.

Both the United States and Canada have contributed liberally towards developing opportunities for workers to get together and discuss problems of national or international importance. Not only have the entomologists themselves been brought more frequently together, but chemists, botanists, agronomists, animal husbandmen, agricultural engineers, and other scientists, have met with them to discuss and develop measures of control.

This Society and the American Association of Economic Entomologists have contributed much to the advancement of applied entomology, not only in bringing workers together, but also in publishing their findings.

In the main, however, the remarkable development of economic entomology in North America is a direct result of the many introduced insect species which have become established without their natural enemies. No other nations in the world have had to face the insect menace as have the United States and Canada. As one who has been associated with the work for more than a quarter of a century, I take this opportunity of paying my humble respects to the loyal band of workers who have assumed this responsibility and thus raised the science of applied entomology to the high position in America which it now occupies.

THREE NEW APHIDS FROM COLORADO

C. P. Gillette and M. A. Palmer,
Colorado Agricultural Experiment Station.

Lachnus lasiocarpæ n. sp.

Fundatrix.—(Plate I, Fig. 1). Described from type and three paratypes taken on *Abies lasiocarpa* on Fall River, Estes Park, Colorado, July 7, 1923, by the junior author.

Color: (In old examples which had probably been rubbed.) Entire dorsum dark brown to black, with white powder marking median line and lateral portions of thorax; antennæ pale, with tips of joints and entire VI blackish; legs black with bases of femora and tibiæ yellowish.

Measurements: Body 5 mm. long, 3 mm. wide; hind tibiæ 3.2 mm.; antennæ 1.9 mm.; joints as follows: III, .76 mm. (.70 mm.);* IV, .30 mm. (.20–.26 mm.); V, .32 mm. (.30 mm.); VI, .20 mm. + .04 mm.; cornicles, .45 mm. in diameter.

Structural characters: Secondary sensoria on antennal joint III, 0; IV, 0 to 1; V, 1; hairs spine-like, .15 mm. long on body and on outer side of hind tibiæ, .12 mm. on cornicle base.

Apterous Summer Viviparous Female.—(Plate II, Figs. 4, 5 and 6). Described from type and two paratypes taken on *Abies lasiocarpa* on Black Mesa, Colorado, August 12, 1920, by the junior author.

Color: Body brown, mottled with powdery secretion; antennæ pale with tips of joints dusky; legs dusky with bases of femora and tibiæ yellowish; cornicles black.

Measurements: Body 5 mm. by 3 mm.; hind tibiæ, 3.50 mm.; hind tarsi, .50 mm. or 1/7 to 1/6 of tibiæ; antennæ 2 mm.; joints as follows: III, .80 mm. (.80 to .90 mm.); IV, .35 mm. (.34 to .44 mm.); V, .40 mm. (.40 to .45 mm.); VI, .22 to .25 mm. + .07 mm. (.04 to .07 mm.); cornicles, .30 to .50 mm. in diameter at base.

Structural characters: Secondary sensoria on antennal joint III, 0; IV, 2 (2 to 3); V, 2 (2 to 3); hairs spine-like, numerous, set at angle of 50 degrees, .16 mm. long.

Habitat, on bark of twigs of *Abies lasiocarpa*. Taken on Black Mesa, Fall River, and Rabbit Ears Pass, Colorado; fundatrices and apterous viviparæ; three collections; apparently rare.

This species appears to resemble *Lachnus grossus* Kalt., but differs from Kaltenbach's description in color, being brown

*Numbers in parentheses indicate variations in paratypes.

and more or less marked with powder and covered with numerous long hairs, instead of black and naked, shining in parts. It differs also as to host, *L. grossus* feeding on *Picea abies* (*Pinus Abies*). From six specimens labelled *Lachnus grossus* Kalt. from *Abies sibirica* sent by Cholodkovsky, (Plate II, Figs. 1, 2 and 3), *L. lasiocarpæ* differs by possessing longer antennal joints, especially joint IV, and longer tarsi (see Figs. 1-5). Cholodkovsky's specimens, apteræ, measuring as follows: Antennal joints III, .70 to .80 mm; IV, .18 to .33 mm.; V, .32 mm.; VI, .20 to .29 mm. + .04 to .08 mm.; tarsi, .30 to .35 mm.; hind tibiæ, 2.70 to 3.50 mm.; hind tarsi equalling one-tenth to one-ninth length of hind tibiæ.

Types in U. S. National Museum Catalog No. 42082; paratypes in collection of Colorado Agricultural Experiment Station.

Symydobius intermedius n. sp.

Fundatrix.—(Plate I, Fig. 3). Described from type and one paratype taken on *Betula* sp. at Fort Collins, Colorado, April 7, 1916, by L. C. Bragg.

Color: Olive green with broad bands of dusky brown on all segments; antennæ with black and white annulations, legs dusky throughout; cornicles pale.

Measurements: Length of body, 2.66 mm.; hind tibiæ, 1.50 mm.; antennæ, 2.20 mm.; joints: III, .89 mm.; IV, .47 mm.; V, .44 mm.; VI, .19 mm. + .07 mm.; cornicles, .08 mm.; cauda, .05 mm.

Structural characters: Secondary sensoria circular, arranged in a single row, 13 (8 in paratype) in number. All other characters as in apterous summer viviparæ.

Apterous Summer Viviparous Female.—(Plate I, Fig. 6; Plate II, Figs. 7, 8 and 15). Described from type and four paratypes taken on *Betula* sp., at Ft. Collins, Colorado, July 13, 1915, by L. C. Bragg.

Color: Olive green with dusky bands often coalescing, cornicles pale, legs dusky throughout, antennæ annulated.

Measurements: Length of body, 2.50 mm.; hind tibia, 1.80 mm.; antennæ, 3 mm.; joints: III, 1.00 mm. (.82 to 1.05 mm.); IV, .65 (.57 to .69 mm.); V, .53 (.55 to .61 mm.); VI, .26 (.22 to .27 mm.) + .13 (.10 to .14 mm.); cornicles, .07 mm.; cauda, .05 mm.; beak, .50 mm., attaining second pair of coxæ.

Structural characters: Secondary sensoria circular, arranged in a single row along practically entire third antennal joint, 19 (16 to 22) in number; hairs pointed, on body .05 to .08 mm. in length, somewhat spine-like; on antennæ, .03 to .04 mm. in length, about equal to one-half of diameter of corresponding part of antennal joint, fine, hardly spine-like; on cauda and anal plate somewhat longer than on body and numerous and bushy in arrangement; imbrications on cornicles and

antennæ finely setose; cornicles truncate, usually with flange; cauda semilunar, broader than long; anal plate indented, with swelling on either side of cauda, resembling a pair of plates; frontal tubercles present but shallow; vertex with tubercular-shaped projection; first antennal joints slightly gibbous; ocular tubercles present.

Alate Viviparous Female.—(Plate I, Fig. 4, and Plate II, Figs. 9, 13 and 14). Described from type and seven paratypes taken along with apterous viviparæ described above.

Color: Tawny olive with dusky cross-bands on abdomen, cornicles pale, antennæ annulated, legs dusky to black, fore wings with veins heavily bordered, the anal and cubital being the most broadly bordered.

Measurements: Length of body, 2 mm.; hind tibiæ, 1.40 mm ; antennæ, 2.40 mm.; joints: III, .75 (.64 to .88 mm.); IV, .55 (.47 to .60 mm.); V, .50 (.44 to .52 mm.); VI, .22 (.16 to .27 mm.) + .13 (.10 to .14 mm.); cornicles, .07 mm.; cauda, .05 mm.; beak, .30 mm., attaining second pair of coxæ.

Structural characters: Secondary sensoria circular to oval, arranged in a single row along practically entire length of antennal joint III, 12 and 16 (12 to 20) in number; fore wings with radial sector distinct, but not as heavy as other veins; frontal tubercles hardly evident; other characters as given for apterous viviparæ.

Apterous Oviparous Female.—(Plate I, Fig. 5; Plate II, Figs. 11, 12, 16 and 17). Described from type and five paratypes taken on *Betula*, at Fort Collins, Colorado, September 25, 1915, by L. C. Bragg.

Color: Clay color with broad dusky cross-bands on all segments except abdominal segments 7 and 8; anal plate tinged with pinkish, otherwise as in viviparæ.

Measurements: Length of body, 2.80 mm.; hind tibiæ, 1.40 (1.22 to 1.50 mm.); antennæ, 2.50 mm.; joints as in fundatrix, excepting unguis, which is .10 (.10 to .14 mm.).

Structural characters: Terminal segments of abdomen slightly prolonged to form ovipositor. Hind tibiæ but slightly swollen on proximal half or two-thirds, thickly strewn for almost entire length with small flat sensoria. Other characters as given for apterous viviparæ.

Male.—(Plate I, Fig. 7; Plate II, Fig. 10). Described from type and one paratype taken October 15, 1917, another paratype, October 7, 1911, on *Betula* sp., at Fort Collins, Colorado, by L. C. Bragg.

Color: Dusky brown with pale cornicles, antennæ and legs as in viviparæ.

Measurements: Length of body, 1.95 mm.; hind tibiæ, 1.10 mm.; antennæ, 2 mm.; joints: III, .75 (.66 to .81 mm.); IV, .50 (.47 to .60 mm.); V, .40 (.40 to .43 mm.); VI, .20 (.15 to .21 mm.) + .12 (.11 to .13 mm.); cornicle, .05 mm.

Structural characters: Apterous; secondary sensoria on antennæ found only on joint III, 10 to 15 in number, arranged as in females. Indeed the only character by which the male can be distinguished seems to be the copulatory organs, and slightly smaller size.

Habitat, on bark of *Betula fontinalis*, at Fort Collins, Boulder, Estes Park, Stove Prairie near Bellvue, and Crawford, Colorado; fundatrices April 7; apterous summer viviparæ, June 2 to October 7; alate viviparæ, June 2 to August 9, apterous oviparæ, September 25 to October 13; apterous males, October 15; twenty collections; fairly common.

This species is distinguished from *oblongus* Heyd. by the indented anal plate and the extent of the sensoria along entire length of joint III. Also Van der Goot (1915, Holland Plant Lice) mentions secondary sensoria on joint V of the male.

From *S. americanus* Baker, this species differs in the shorter unguis.

Types in U. S. National Museum, Catalog No. 42819; paratypes in collection of Colorado Agricultural Experiment Station.

Periphyllus brevispinosus n. sp.

Apterous Summer Viviparous Female.—(Plate I, Fig. 8; Plate II, Figs. 18 and 23). Described from type and seven paratypes taken on under side of leaves of *Acer glabrum* at Idaho Springs, Colorado, June 17, 1926, by the junior author.

Color: Brown, mottled dark and light, with cornicles yellow; legs and antennæ yellowish with distal ends of joints dusky.

Measurements: Length of body, 2.40 mm.; width, 1.50 mm.; hind tibiæ, .85 mm.; antennæ, 1.30 mm.; joints: III, .42 mm. (36 to .47 mm.); IV, .28 mm (.22 to .30 mm.); V, .23 mm. (.20 to .23 mm.); VI, .14 mm. + .20 mm. (.18 to .20 mm.); cornicles, .10 mm.; spines on body, .10 to .12 mm.

Structural characters: Secondary sensoria circular, arranged in an irregular row along entire length of antennal joint III in alate viviparæ, 15 (11 to 19) in number, none (rarely 1) on IV; hairs pointed, heavy spine-like, .10 to .13 mm. long on body, fine and .03 to .05 mm. long on antennæ and legs; antennæ imbricated throughout: cornicles truncate, narrower in middle, reticulate on distal 2/3; imbricated on proximal 1/3; cauda rounded semi-lunar; anal plate rounded; ocular tubercles present.

Alate Viviparous Female.—(Plate I, Fig. 9; Plate II, Figs. 19 to 22). Described from type and nineteen paratypes taken on *Acer glabrum* on under side of leaves, at Idaho Springs, Colorado, June 17, 1926, by junior author.

Color: Dark brown with black head, thorax, lateral spots and dorsal bands, especially on terminal segments of abdomen; cornicles, antennæ and legs as in apteræ; wings hyaline, stigmæ dusky brownish.

Measurements: Length, 2.25 mm.; hind tibiæ, 1 mm.; antennæ, 1.55 mm.; joints: III, .55 mm. (.43 to .55 mm.); IV, .36 mm. (.28 to .40 mm.); V, .30 mm. (.25 to .30 mm.); VI, .14 mm. + .20 mm. (.17 to .22 mm.); cornicles, .11 mm.; cauda, .14 mm.

Structural characters: Secondary sensoria, circular, 15 (11 to 19) in number, in irregular double row along entire length of antennal joint III of alate viviparæ, joint IV with none or rarely one; forewings with media twice branched; hind wing with both media and cubitus present.

No collections were taken other than the types and paratypes, but specimens were very abundant.

Apparently rare or confined to type locality.

Types in U. S. National Museum, Catalog No. 42816; paratypes in collection of Colorado Agricultural Experiment Station.

Trama oculata n. sp.

Apterous Viviparous Female.—(Plate II, Figs. 23, 24, 25 and 26). Described from type and several paratypes taken under stone with ants, in foothills near Ft. Collins, Colorado, February 23, 1930, by Esther Lanchester and Bernard Travis.

Color: Pale whitish in younger examples, olive brown in older individuals; legs yellowish with tarsi of first two pairs of legs dusky; antennæ brownish yellow.

Measurements: Body, 3 mm. long; hind tibiæ, 1 mm.; hind tarsi, .95 mm.; antennæ, 1.50 mm.; joints: III, .45 mm.; IV, .19 mm.; V, .29 mm.; VI, .22 + .06 mm.; beak attaining middle of abdomen; last three joints measuring .23 mm., 22 mm., and 05 mm., respectively.

Structural characters: Secondary sensoria flat, indistinct and irregular in form, scattered, about seven on III, one on IV, and three on V; primary sensoria long and flat; unguis conical; hairs pointed, fine, numerous and drooping, about .03 mm long, on antennæ and legs equalling about one-half diameter of joint; cornicles lacking entirely; cauda semilunar, broader than long; frontal tubercles lacking; eyes normal, composed of more than 15 facets, ocular tubercle divided and consisting of three finger-like facets.

Alate Viviparous Female.(Plate II, Fig. 27). Described from type taken on roots of *Taraxacum officinale* in greenhouse of the Great Western Sugar Company, at Longmont, Colorado, January 18, 1930, by A. C. Maxson.

Color: "Thorax quite dark, almost black and dark dorsal bands on abdomen, one on each segment, darkest on 8th."*

Measurements: Body, 2.50 mm. long; hind tibiæ, .90 mm.; hind tarsi, .88 mm.; antennæ, 1.30 mm.; joints: III, .40 mm.; IV, .19 mm.; V, .27 mm.; VI, .19 mm. + .04 mm.

Structural characters: Secondary sensoria not apparent on III, two on IV; two or three on V, arranged along posterior side of joints; cornicles apparently absent; fore wings with radial sector very slightly curved, media once forked, stigma rather broad; other characters as in apteræ described above.

*From notes by A. C. Maxson.

This species was first brought to our attention by the collection of apteræ by Miss Esther Lanchester and Mr. Bernard Travis, students in Entomology, February 23, 1930. In the latter part of March we received a vial containing apteræ of this same species, taken with ants on roots of *Taraxacum officinale* in the greenhouse, from A. C. Maxson, in Longmont, Colorado. On learning that we were ready to publish the species, Mr. Maxson kindly loaned us his alate example and his notes on the species. Notes are as follows:

"Several large colonies discovered on roots of dandelions growing in the Great Western Sugar Co. greenhouse at Longmont, Colo., Dec. 14, 1929.

"These colonies were located just below the crown and surface of the soil. The lice were all head downward. When disturbed, the lice throw the long hind tarsi outward, giving the colony a hairy appearance. All colonies attended by a small red ant.

"These colonies were composed almost wholly of apterous females and young of various sizes. There were two or three pupæ found also. There were two colors of individuals. The younger ones were creamy white, with legs, all but VI of the antennæ and part of V with a brownish tinge. Fore and middle tarsi dark brown. Terminal joint of beak brown with tip darkest. Tip of hind femora and tip of long hind tarsal joint dark also. Compound eyes dark. Tubercle appears somewhat pointed.

"Body covered with fine somewhat curved hairs which are most numerous and longest near middle portion of segments. Body segments clearly discernible. Body distinctly marginated. Tip of abdomen dusky or brownish. Prothorax slightly dusky. Two lateral depressions showing dark at inner margins. Head dusky with faint light median line. Anal plate dusky. Tip of abdomen sometimes with a greenish tinge.

"Some darker individuals have a greenish tinge on body segments. This is darkest toward tip of body. The 8th segment darkest."

This species is distinguished from *Trama troglodytes* Heyden by the presence of eyes of more than "a few facets," from which character it is given its name. The absence of cornicles forbids its being placed under *Protrama* or *Neotrama*. Indeed it differs from *Trama* in the larger size of the eyes and absence of cornicles even in the alatæ, but we hesitate to erect a new genus.

Types in U. S. National Museum, Catalog No. 43001; paratypes in collection of Colorado Agricultural Experiment Station.

EXPLANATION OF PLATES.

PLATE I.

Lachnus lasiocarpæ n. sp. 1, fundatrix; 2, apterous summer viviparous ♀.

Symydobius intermedius n. sp. 3, fundatrix; 4, alate viviparous ♀; 5, oviparous ♀; 6, apterous summer viviparous ♀; 7 ♂.

Periphyllus brevispinosus n. sp. 8, apterous summer viviparous ♀; 9, alate viviparous ♀.

PLATE II.

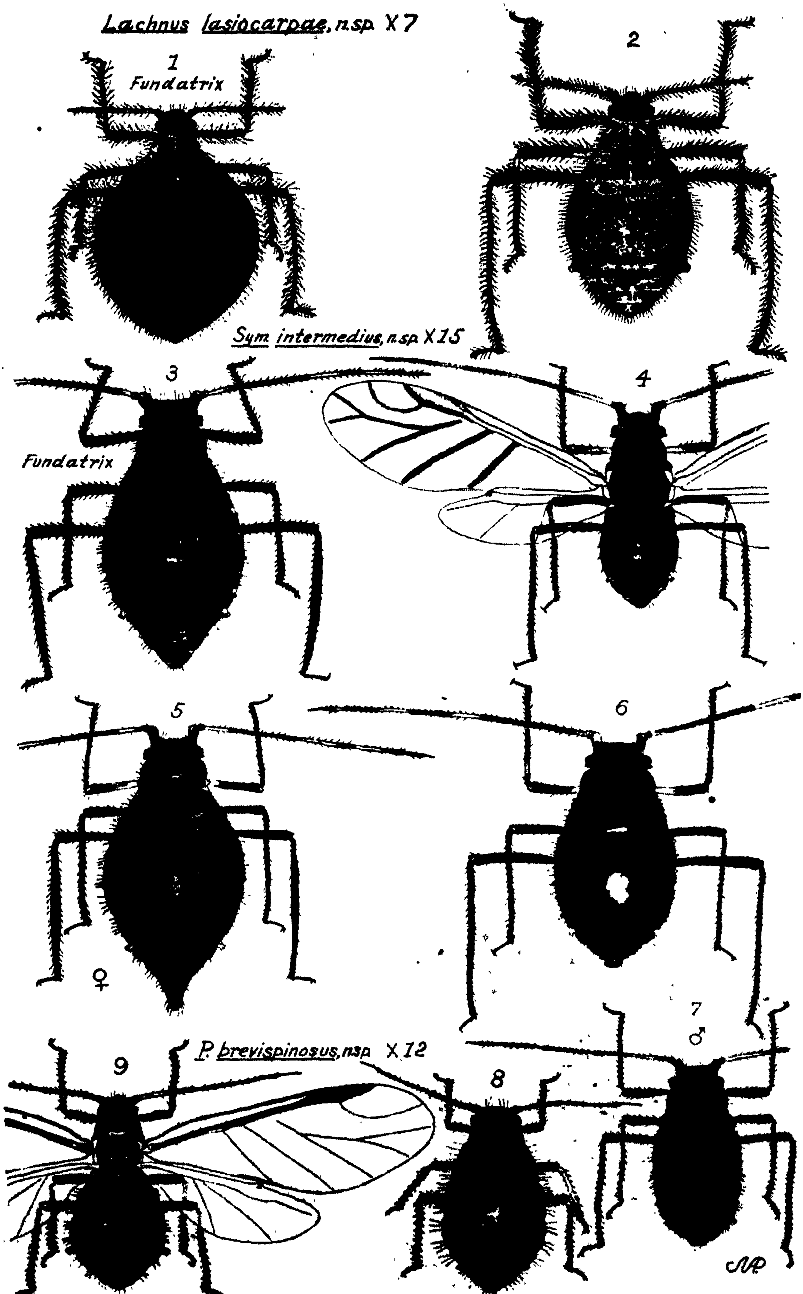
Lachnus grossus Kalt. 1, antenna of apterous summer viviparous ♀; 2, hind tarsus, and 3, middle of hind tibia of same.

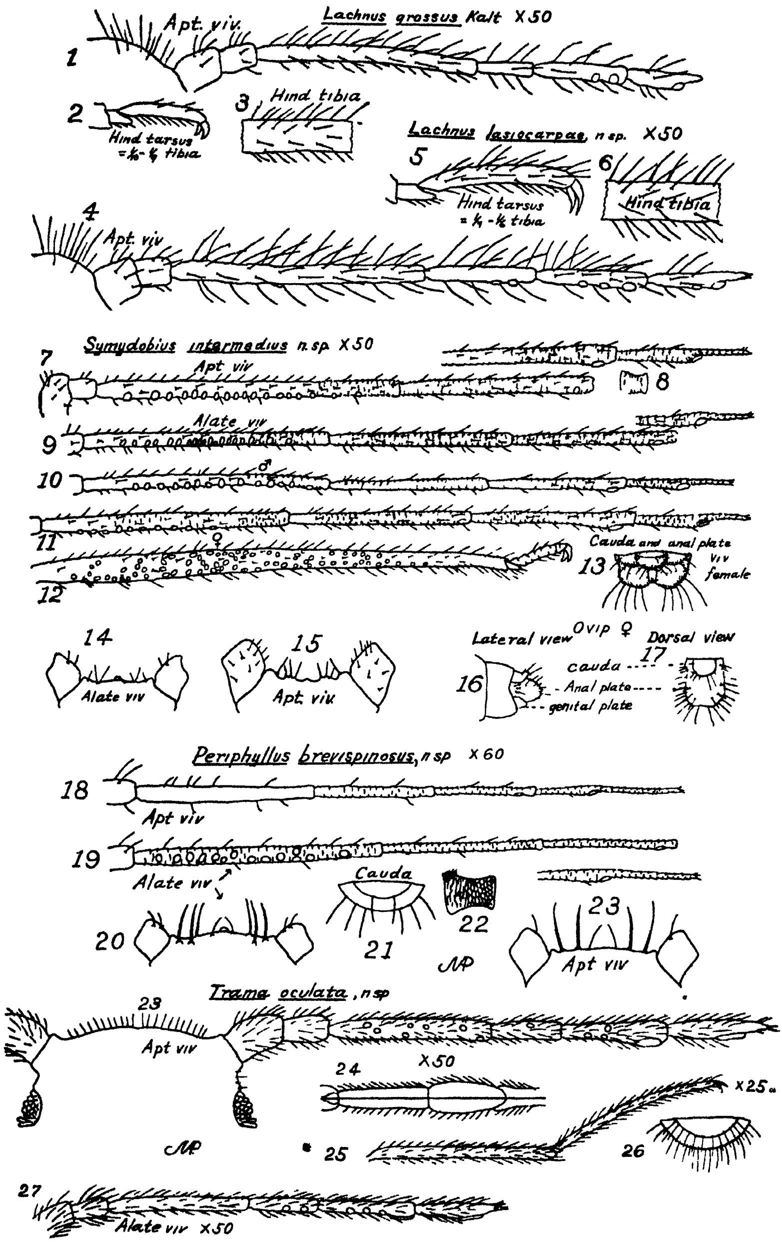
Lachnus lasiocarpæ n. sp. 4, antenna of apterous summer viviparous ♀; 5, hind tarsus, and 6, middle of hind tibia of same.

Symydobius intermedius n. sp. 7, antenna of apterous viviparous ♀; 8, cornicle of same; 9, antenna of alate viviparous ♀; 10, antenna of ♂; 11, antenna of oviparous ♀; 12, hind tibia of same; 13, cauda and anal plate of alate viviparous ♀; 14, vertex of same; 15, vertex of apterous summer viviparous ♀; 16 and 17, cauda, anal plate and genital plate of oviparous ♀.

Periphyllus brevispinosus n. sp. 18, antenna of apterous summer viviparous ♀; 19, antenna of alate viviparous ♀; 20, vertex of same; 21, cauda and anal plate of same; 22, cornicle of same.

Trama oculata n. sp. 23, head and antenna of apterous viviparous ♀; 24, beak; 25, hind tibia and tarsus, and 26, cauda of the same; 27, antenna of alate viviparous ♀.


Lachnus lasiocarpae, n.sp. X 7
1
Fundatrix
2
Sym. intermedius, n.sp. X 15
3
Fundatrix
4
5
♀
6
7
♂
9
P. brevispinosus, n.sp. X 12
8
MP


Lachnus grossus Kalt X 50
Apt. viv.
Hind tarsus
Hind tibia
Lachnus lasiocarpae, n sp. X 50
Hind tarsus
Hind tibia
Apt. viv
Symydobius intermedius n. sp. X 50
Apt viv
Alate viv
Cauda and anal plate viv female
Alate viv
Apt. viv
Lateral view Ovip ♀ Dorsal view
cauda
Anal plate
genital plate
Periphyllus brevispinosus, n sp X 60
Apt viv
Alate viv
Cauda
Apt viv
Trama oculata, n sp
Apt viv
X 50
X 25
Alate viv X 50

NOTES ON THE HABITS OF A DIGGER WASP AND ITS INQUILINE FLIES.

E. J. Newcomer,
U. S. Bureau of Entomology, Yakima, Wash.

One fine day in early April I noticed a large, steely blue wasp running awkwardly along the ground on tip toes. It was carrying a full grown cutworm, longer than itself, which it straddled and held in its mandibles. I had read something of the habits of the digger wasps, as written by Fabre, the Peckhams, and others, and as this occurrence was taking place in a vacant lot next to my laboratory, I seized the opportunity of learning something about digger wasps at first hand. During that season and the next I observed these wasps at every opportunity. Then a house was built on the vacant lot and my observations were brought to an end. But during the two seasons I saw some rather startling things. I am somewhat chagrined, however, to think that I had occupied this laboratory for a number of years in succession without even suspecting the presence of these wasps. I suppose, being a mere economic entomologist, I had been too narrowly concerned with such ordinary things as the codling moth and the San Jose scale. Once my attention was directed to the wasps, however, my economic training possibly enabled me to see some things that were overlooked or even deliberately put aside by some of the earlier observers.

What is this wasp, where is she going with her burden and what will she do with it? If you are familiar with the writings of Fabre or the Peckhams, you know the answers to these questions, at least in a general way. But are you so familiar with many of the difficulties under which this wasp works, harrassed as she often is by squirming cutworms, aggressive ants, and ever-present inquiline flies?

The wasp I am writing of is known as *Podalonia luctuosa* (Smith), a Sphecid, evidently a relative of the famous *Ammophilas*,* though a much larger and stouter insect. These wasps were abundant during April and May about my laboratory

*The *Ammophilas* are now included in the genus *Sphex*.

at Yakima, Washington, and on bright, warm days a dozen or more might be seen hunting or digging. The terrain was typical of vacant lots—weeds and grass growing irregularly, bare spots, and a rubbish heap. I had thrown much old automobile oil on this rubbish heap at various times, and the mixture of oil and ashes seemed very attractive to the wasps. They dug many nests in it with no apparent discomfort, although I wondered how the young could thrive in such an oily place. Perhaps they did not. If the day was warm and quiet, the wasps were often at work as early as 8 o'clock in the morning, and worked until 4 or 5 o'clock in the afternoon. Their activities were considerably retarded by cloudy or windy weather, but not stopped altogether unless it became cold.

BEHAVIOR OF WASPS.

There are many variations in the behavior of these wasps, but first let us follow a typical individual through all of her activities. The habits of *luctuosa* have never been recorded, although Prof. J. B. Parker has made some observations on a related species, *Podalonia violaceipennis* (Lep.) (as *Psammophila violaceipennis* (Lep.)*

The *Ammophilas* usually construct their nests before obtaining provisions, but the *Podalonias*, which place but one caterpillar in a nest, capture their prey first. *Luctuosa* hunts rapidly, almost feverishly, running from grass clump to grass clump, inspecting the ground carefully, for the cutworms she seeks are nocturnal feeders, and lie hidden by day. She knows when she has found a cutworm's hiding place, and she digs frantically, using her fore legs, and throwing the dirt back like a dog digging for a squirrel. She soon uncovers the luckless worm and drags it forth, twisting and squirming. Sometimes the worm senses the impending danger and crawls out of the earth at a little distance. The wasp usually sees it, however, and pounces on it. If it is too small, she may sting it once and leave it, or leave it without stinging it at all. To suit her needs, it must be at least as large as herself, for it is to provide food for one of her offspring.

The wasp knows which is the head end of the cutworm, and, seizing it by the thorax, she administers a sting to one of the thoracic segments, apparently the first. Then, working the worm forward with her fore legs and jaws, she stings each succeeding segment, the movements of the worm gradually ceasing. This stinging process is more or less irregular, as the Peckhams observed, but usually most of the segments are stung. Sometimes, however, only four or five of the anterior segments receive the sting. Whether or not the sting touches each ganglion is problematical, but at least the poison paralyzes most of

*Parker, J. B. Notes on the nesting habits of some solitary wasps. Proc. Ent. Soc. Wash., Vol. XVII, p. 70, 1915.

them and renders the worm incapable of normal movements. Fabre believed it was essential that the worm be paralyzed but not killed, while the Peckhams considered this secondary to the immediate necessity of rendering the worm practically motionless so that it might be handled and would not kill the delicate wasp larva that would later feed on it. The Peckhams found that with *Ammophilas* and other species storing more than one worm in a nest, some of the worms usually died before the wasp larva had started feeding on them, but that this made no difference to the larva. The single worm used by *Podalonia* is usually alive when the wasp's egg hatches, but is invariably dead some time before the larva has finished feeding (Pl. II, Fig. 2).

Following the stinging, the wasp often spends some time squeezing or chewing the cutworm just back of the head with her mandibles. Fabre calls this "malaxation" (my French dictionary gives the verb "malaxer" as a druggists' term meaning "to work up"), and says that this munching of the worm is for the purpose of rendering insensible the brain, which can not easily be reached with the sting. The Peckhams, also, have interpreted it to be for the purpose of further quieting the worm. It seemed to me that the squeezing was mostly on the first thoracic segment, and while that may affect the brain, it appeared also to be for the purpose of finding out whether the worm was sufficiently paralyzed, for I have seen a wasp sting a worm several times, "malax" it, and then sting it again. The wasp also sometimes sucks up the liquid regurgitated from the worm's mouth after this treatment, but this habit is undoubtedly incidental. I am inclined to believe with the Peckhams that the instinct of paralyzing and "malaxing" the worm does not extend beyond the immediate effect, that of putting the worm in a condition to be managed easily by the wasp.

Once the cutworm is properly subdued, the wasp grasps it firmly by the neck, ventral side up and, straddling it, proceeds to run with it. There is a great advantage in carrying the cutworm upside down, for it naturally curls ventrally a bit, and this keeps it from dragging on the ground. I have seen a wasp with a cutworm so imperfectly paralyzed, however, that its hind legs took hold of every stem and leaf, greatly hindering progress. The wasp usually carries her worm up into a clump of grass or weeds and hangs it over the axil of a leaf, or sometimes she hangs it over a brushy twig in the rubbish heap. The advantage of placing the cutworm off the ground is obvious, for there are many large, red *Formica* ants wandering about, and an occasional *Calosoma* beetle, even in the day time, to say nothing of other wasps, and if the paralyzed cutworm were left on the ground for any length of time, it would be appropriated by some of these other insects.

After stinging the cutworm, the wasp may carry it twenty or thirty feet before cacheing it, and then may dig her nest several feet from the cutworm, although it is often within two feet. Before leaving the cutworm, the wasp circles about it and returns to it two or three times, as though to familiarize herself with the location. She then hunts for a suitable place for her nest, and she may finally decide upon a site 20 feet or more from the cutworm cache.

The wasp uses her mandibles and fore legs to dig with, kicking the dirt out behind with her middle and hind legs. She soon makes quite a hole in the sandy soil, and as the digging proceeds she must bring up load after load of soil particles held tightly between her mandibles and fore legs. These are dropped at the entrance, and are often kicked some distance as the wasp starts back into the hole (Pl. I, Fig. 1). Large sticks and stones and lumps of coal may be brought out and it is remarkable how readily the wasp can move large obstacles While the digging is going on in the nest the wasp's wings buzz loudly, but they are quiet when she is outside. I have often located a wasp at work by listening for this periodical buzzing. The construction of the nest, which is about two inches deep and somewhat enlarged at the bottom, requires from ten minutes to half an hour. The work is usually continuous, although sometimes a wasp will flatten herself out at the entrance to the hole for a brief rest.

When the nest has been completed, the wasp returns to her cutworm. If this is near at hand, it is soon found and carried to the hole. But if it is some distance away she may search for a long time before finding it. I came across a wasp one day that was just completing her nest, and I followed her to her cutworm cache twenty feet away. I could see the cutworm hanging in a grass clump, but the wasp had difficulty in finding it. She passed within a few inches of it several times, wandering some distance away each time. Then she returned to her nest as though to get her bearings, and this time she was able to go almost straight to the cutworm. But then she apparently forgot where the nest was, and carried the cutworm about for a long time while searching for it. Finally she had to deposit the cutworm in another grass clump and go in search of the nest without it. This time she found the nest and cleaned it out. Then she rested a moment before carrying the cutworm to it. I wondered whether this wasp had a poorer memory than her sisters; certainly she lacked the assurance that most of them had. Possibly some disturbing circumstance, such as my presence, had confused her.

When a wasp arrives at her nest with a cutworm, she drops it with its head at the mouth of the nest (Pl. I, Fig. 2), enters the hole, turns around, comes up, and drags the cutworm down after her. Occasionally she cleans the nest out a bit before pulling the victim in. Once it is safely deposited at the bottom of the nest, she deposits an egg on it. I was never able to see this performance, but it requires about a minute, after which the wasp emerges from the nest and immediately begins scratching dirt into the hole. The process of filling the hole usually requires only about five minutes, but sometimes it takes longer, and frequently sticks and stones of various sizes are seized and placed in it. The Peckhams observed one *Ammophila* pounding down the soil with a small stone held in her mandibles. *Podalonia luctuosa* often carries small stones into the hole, pressing them against the dirt, with her feet braced and wings buzzing, as though to pack the soil more effectually. These stones are always left in the hole but their primary use is evidently to make the soil as firm as possible, for the wasp also

presses against the soil with her head in the same manner. Any large sticks or twigs that may be scratched into the hole inadvertently are taken out again, as they interfere with properly filling the excavation.

When the hole has been filled, there follows a rather indiscriminate scratching of dirt on the surface. This dirt is often scratched away from the hole instead of toward it, but the general result is to obliterate totally any signs of the nest. I have seen a wasp continue this apparently aimless scratching for nearly half an hour, her accuracy or instinct gradually becoming more vague until finally she got entirely away from the location of the hole. After having completed the nest the wasp may immediately begin a search for another cutworm or she may fly off and feast herself at the mustard blossoms and do no more work that day.

The choice of a site for the nest is not always fortunate. Loose sand may be encountered, or ground so hard it can not be penetrated. In one instance, a wasp started her first attempt at making a nest at 12:15, her second at 12:25, her third at 12:28, and her fourth at 12:40, completing this one and putting the worm into it at 1:05. The first excavation, at least, was made in the rubbish heap, and was probably abandoned on account of the presence of too much oil in the ashes of the heap. At another time a wasp attempted to dig a nest in hard soil. After some minutes of effort, she turned around and kicked some dust into the shallow hole, with a gesture that can only be described as one of disgust, and departed.

Sometimes a wasp is unable to find her cutworm after having constructed her nest. I observed one case that was perhaps due to my interference. I found a wasp digging her nest, and I placed a healthy cutworm near it but the wasp ignored the cutworm although she had to walk over it; her instincts at the moment were concentrated on nest building. Soon the cutworm crawled into the hole she was digging. The wasp promptly dragged it out and tried to sting it, but the cutworm was very active and the secretion from its mouth repelled the wasp. Four or five times the cutworm retreated into the hole, as the wasp stopped to clean herself, and as many times she hauled it out again.

The cutworm finally buried itself a couple of inches away while the wasp went on digging. She may have become confused by these interruptions, for when her nest was completed she was unable to find the cutworm she had prepared for it. After a search of about five minutes she gave it up, and, apparently forgetful of the cutworm that was within two inches of her nest, or unwilling to attack it again, she ran off in search of another victim. Within five minutes she found one a couple of feet away, paralyzed it, and deposited it in a nearby grass clump. Then she returned to the nest that was already constructed, cleaned it out and buried the cutworm in it. The whole process occupied over an hour. From this it is evident that the wasp's instincts are far from being iron bound. The usual procedure is to capture the prey first, and then construct its crypt. But if her memory fails her and she cannot find her victim, she is entirely capable of

reversing the process, and going in search of another worm with which to provision the nest she has already constructed.

On another occasion I saw a wasp digging excitedly under one end of a short stick. Soon a large cutworm crawled out from beneath the stick and the wasp pounced upon it and attempted to sting it, but she seemed to be repelled by something. Twice more she tried to sting, and both times she recoiled. Evidently she was greatly affected by the liquid exuding from the cutworm's mouth, for each time she sprawled in the dust as though to rid herself of something, and each time she carefully cleaned her antennæ and legs before going back. Finally she gave it up altogether and allowed the cutworm to escape. Why should this wasp's behavior differ from the others? Was she more fastidious, or could this particular cutworm have been suffering from some disease that made it repellent to her? Is it possible that the cutworm was parasitized? It may have been, but I have reared large Tachinid flies from cutworms taken from the nests of this wasp, giving evidence that at least sometimes she is unaware that her victim is already doomed, and that her own offspring will not have the provender she thinks is being stored for it.

I have already mentioned the large red *Formica* ants* which at times interfere with the wasp's labors. If one of these pugnacious ants is encountered while the wasp is carrying her prey, a lively time ensues. I witnessed one encounter in which the ant got hold of the cutworm near its head, immediately causing the wasp to become greatly excited. She tried to pull the cutworm away, and then began to sting it segment by segment, as though the movements caused by the tugging of the ant made her believe it was insufficiently paralyzed. Although she was many times larger than the ant, she was unable to pull the cutworm away and eventually flew off, leaving it to the ant.

Another wasp had just brought her prey to the entrance of her nest when an ant came up and took hold of it. The wasp immediately began running rapidly with the worm and shook the ant off. The ant retreated into the wasp's nest, and attacked the cutworm again when she returned with it. This performance was repeated several times. The last time the ant was carried some distance from the nest before being shaken off, and did not return to it. The wasp ran about excitedly for several minutes with her cutworm, but finally put it safely up into a grass tuft. Then she started digging a new hole, seemingly fearing to return to the first one. Is that intelligence, or is it fear, or merely instinct?

The *Podalonias* are distinctly solitary and have no love for one another. One day I witnessed a triangular battle When I first came upon them, two wasps were fighting, but they soon stopped and wasp No. 1 scurried to a grass clump where she had a cutworm cached. She carried it to a nest she had constructed, put it in, and deposited an egg upon it. She then began filling up the hole. Wasp No. 2 also had a cutworm and a nest nearby, and she put this cutworm into her

*A variety of *Formica rufa* L.

nest only a minute later than wasp No. 1, and began filling up the hole. Shortly, a third wasp came along and locked mandibles with No. 2. These two wasps were the same size, and after a little skirmishing No. 3 departed and No. 2 went on working. No. 3 then came upon No. 1 at work filling up her nest. A fight ensued, and as No. 1 was smaller than No. 3, she got the worst of it and departed. No. 3 then tried to dig up the cutworm No. 1 had just buried, but she seemed to be unable to find it, and dug mostly a couple of inches from the nest. No. 1 came back but was beaten off again. No. 3, not finding the cutworm, started away and ran across the location of No. 2's nest, which, in the meantime, had been completely filled. In spite of the obliteration of all visible signs of a hole, No. 3 apparently sensed the presence of a cutworm and started to dig. In fifteen minutes she had reached the cutworm, which she dragged to the surface. She then proceeded to inspect it, and finding the egg of wasp No. 2 on it, she pinched and chewed this until nothing was left of it but the shell. Then she carefully stung the cutworm in several places, and "malaxed" it, although it had already been paralyzed by its original captor. This done, she proceeded to clean out the hole made by No. 2, put the cutworm back into it, and deposited her own egg upon it. I dug this cutworm up later and found the eggshell of wasp No. 2 on the sixth segment, and the egg of No. 3 on the seventh segment. Is it possible that this individual, Nomada-like, had become a cuckoo, and was depending on her sisters to provide nests and provisions for her young?

I tried placing wasps in a large screen cage with soil in the bottom, and stocked with cutworms and with mustard blossoms in water for food. This arrangement proved to be unsatisfactory. The wasps spent much time fighting one another and trying to get out of the cage, and I learned nothing that I could not learn from the unconfined wasps.

LARVAL HABITS.

In order to observe the habits of the larvæ of *Podalonia*, I dug up many of the nests and placed their contents in small tin salve boxes with a small quantity of earth. I found that the wasp attaches her egg to one of the anterior or medial segments of the cutworm, placing it near the lateral line, on either side, but not ventrally (Pl. I, Fig. 3). In twenty cases recorded, one egg was placed on the third segment, one on the fourth, three on the fifth, ten on the sixth, and five on the seventh.

The egg is so translucent that its development may be watched. A day or two after it is deposited it has a rather milky and granular appearance, with circular, transparent areas scattered about. After three days the segmentation begins to be apparent. The egg hatches in eight or ten days at room temperature, and it would probably hatch sooner in the nest where it would be heated by the sun. The actual time of hatching can scarcely be told. The larva's head is at the end of the egg attached to the worm, and, when fully developed, it merely makes a hole in the shell and starts to feed. As it grows, the thin shell gradually slides back until the larva is completely out of it.

Larval growth is rapid, requiring about nine days under artificial conditions (Pl. II, Figs. 1 and 2). The cutworm lives but two or three days after the egg hatches; it shrinks rapidly as the larva develops, and little is left of it but skin when the larva has completed its growth (Pl. II, Fig. 3). The larva then spins a cocoon of brown silk (Pl. II, Fig. 4) the construction of which requires a couple of days. There seems to be but one brood of these wasps in a year; at least I have never seen them after May.

Some of the eggs on cutworms that I dug up failed to develop, probably having been injured in the process of getting them out of the ground. In these cases, the paralyzed cutworm lived two or three weeks instead of only ten or twelve days. I have not reared any of these cutworms to maturity, but noctuids captured about the laboratory at the time these cutworms should mature have been determined by Dr. Busck as *Euxoa testula* Sm. It is possible that more than one species occurred in the vacant lot.

FLIES ASSOCIATED WITH THE WASP.

Now I come to the most interesting part of these observations. It has long been known that certain small flies deposit living offspring in the nests of digger wasps. The Peckhams mention these small flies, but only to say that they had to drive them away, and apparently they were not interested in studying the habits of these intruders. These flies belong to the Sarcophagid tribe Miltogrammini, which has recently been revised by Dr. H. W. Allen.* Dr. Allen mentions the habits of some eight or ten species that prey on the larval food of Sphecid wasps. Several of the observations were made by Prof. J. B. Parker, who has also published some notes on these flies.† A few notes have been published by others.

I have observed three species of Sarcophagid flies associated with *Podalonia luctuosa*. The commonest one is *Hilarella hilarella* (Zett.), a very widespread species that has been found with various wasps. It is a small, active, grayish fly. Often it will be seen closely following a wasp that is carrying a cutworm, making short flights and alighting on convenient weeds to watch the progress of the wasp. And frequently when a wasp is constructing her nest, one or more of these flies may be seen perched on a grass blade or a stone, always with its head oriented toward the wasp (Pl. I, Fig. 1). If the wasp is in the hole or has gone after her cutworm, the fly sits facing the entrance to the nest, occasionally changing its position as though becoming impatient.

Hillarella deposits living young in the nest. I have observed this a number of times, and it was always done after the wasp had dragged her prey into the hole, or while she was pulling it down the hole, and before she had come out again. The fly alights at the mouth of the hole at the proper moment, almost instantaneously drops the maggots

*Allen, H. W. North American species of two-winged flies belonging to the tribe Miltogrammini. Proc. U. S. Natl. Mus., Vol. 68, art. 9, pp. 1–106, 1926.

†Parker, J. B. Loc. cit.

into it, and immediately flies off. On one occasion, I saw a fly alight on the cutworm as it was disappearing down the hole and quickly deposit several larvæ upon it.

The fly larvæ are sticky and adhere readily to the cutworm. They must be extremely active, for I have found, on digging up a cutworm a few minutes after they were deposited, that they were already at work on the wasp's egg I have observed these maggots feeding on the egg in several instances although they do not always seem to do this, as in one or two cases cutworms were dug up that had both maggots and a wasp larva feeding on them. In these cases, the wasp larva invariably dies. The maggots feed rapidly and they usually kill the cutworm before the wasp's egg hatches. By that time they are so large that they literally take the food from the larva's mouth. These maggots feed in the manner usual to fly maggots, either outside or inside of the cutworm. I have found from two to seven individuals in a single worm.

Another fly that can scarcely be distinguished from *Hilarella* without a lens is *Taxigramma* (*Heteropterina*) *heteroneura* (Meig.). It is about the same size as *Hilarella*, and has the same coloration and markings. Under the lens, the two may be distinguished by the wing venation. *Hilarella* has the "distal section of fifth vein scarcely more than half as long as preceding section,"* while in *Taxigramma* the distal section is distinctly longer. The venation of the latter species is somewhat more crowded toward the costa, giving the wings a more delicate appearance.

I have captured many individuals of *Taxigramma* about the nests of *Podalonia luctuosa*, in company with *Hilarellas*, and their habits are apparently the same. In one instance, at least, I reared a male *Taxigramma* from one of the cutworms I had dug up. The only previous record of the habits of this species is by C. N. Ainslie,† who reared it from a grasshopper in Utah. It seems rather odd that there should be two species of these flies very similar in appearance and having the same habits and habitat, unless it is a case of mimicry on the part of one or the other.

The third Sarcophagid is *Metopia leucocephala* (Rossi). This fly is larger and darker colored than the others and has a silvery face. Melander and Brues‡ found it associated with *Halictus pruinosus* Robertson, the maggots apparently feeding on the young of this bee, and it has been reported as parasitic in the nests of *H. sexcinctus* (Fabricius) in Europe. It has also been found about the burrows of *Chlorion* and other Sphecids by several observers, but no very definite information on its habits seems to have been published.

I found *Metopia* to be rarer than either *Hilarella* or *Taxigramma*. This may be due to its different habits. Instead of the larvæ being deposited in the nest after the cutworm has been carried in, they are put in beforehand. The fly sits on a grass blade or a convenient stone

*Allen, H. W. Loc. cit., p. 6.

†Walton, Proc. U. S. Nat. Mus., vol. 48, p. 181, 1914.

‡Biol. Bul. No. 5, p. 20, 1903.

watching the construction of the nest. When the wasp has finished this and has gone for the cutworm, the fly crawls down the hole, deposits its young at the bottom, and comes out before the wasp returns. This method is more uncertain than the other. On one occasion I saw a fly enter a completed nest, but for some reason the wasp never returned with provisions. Later I dug up this nest and found several squirming fly maggots at the bottom. They would never have had anything to feed on, and must inevitably have perished. At another time, a fly had deposited its young in the nest, and when the wasp returned, instead of immediately dragging the cutworm into the hole, she first entered it and cleaned it out, bringing out several loads of earth. Evidently in doing so she also removed the maggots, for I later reared a wasp larva to maturity from her cutworm. The habits of the *Metopia* maggots are similar to those of *Hilarella*. They usually destroy the wasp's egg first and then finish off the cutworm.

I dissected several of these Sarcophagid flies, and in one *Taxigramma* I found 29 larvæ, and in three *Hilarellas*, 14, 19, and 19 larvæ, respectively. These larvæ remained perfectly quiet until freed from the enclosing membrane, when they at once became active. The maggots develop quite rapidly, and those of *Hilarella* pupate in 11 to 15 days after they have started feeding. The flies emerge about four weeks later. In the only case observed, the *Metopia* maggots developed in 11 days and the flies emerged 16 days later.

These inquilines, or guest flies, are distinctly harmful to the wasps, and yet as a rule I do not believe the wasps are aware of their existence. When a fly is following a wasp, it usually remains at a discreet distance; and about the nest it is very unobtrusive, becoming aggressive only when the wasp is dragging its prey into the nest, and hence not in a position to know what is going on in the world above. In one instance that I noted, however, the presence of the flies seemed to be known to the wasp. Before she had finished her nest, she had an audience consisting of two *Hilarellas* and one *Heteropterina*. These flies were probably not only watching the progress of the nest but were also watching one another. At least they changed positions frequently, apparently for the purpose of trying to secure the best point of vantage. This flying about seemed to be noticed by the wasp; for after digging for a time she stopped, walked about the mouth of the nest for a few moments, and then suddenly flew fifty feet away and alighted on a mustard plant. The flies waited for some time, but the wasp never returned to the nest. Evidently the number of flies and their restlessness had warned her of impending danger.

The wasp whose habits are described in this paper was very kindly identified for me by Mr. S. A. Rohwer, and the flies by Dr. J. M. Aldrich.

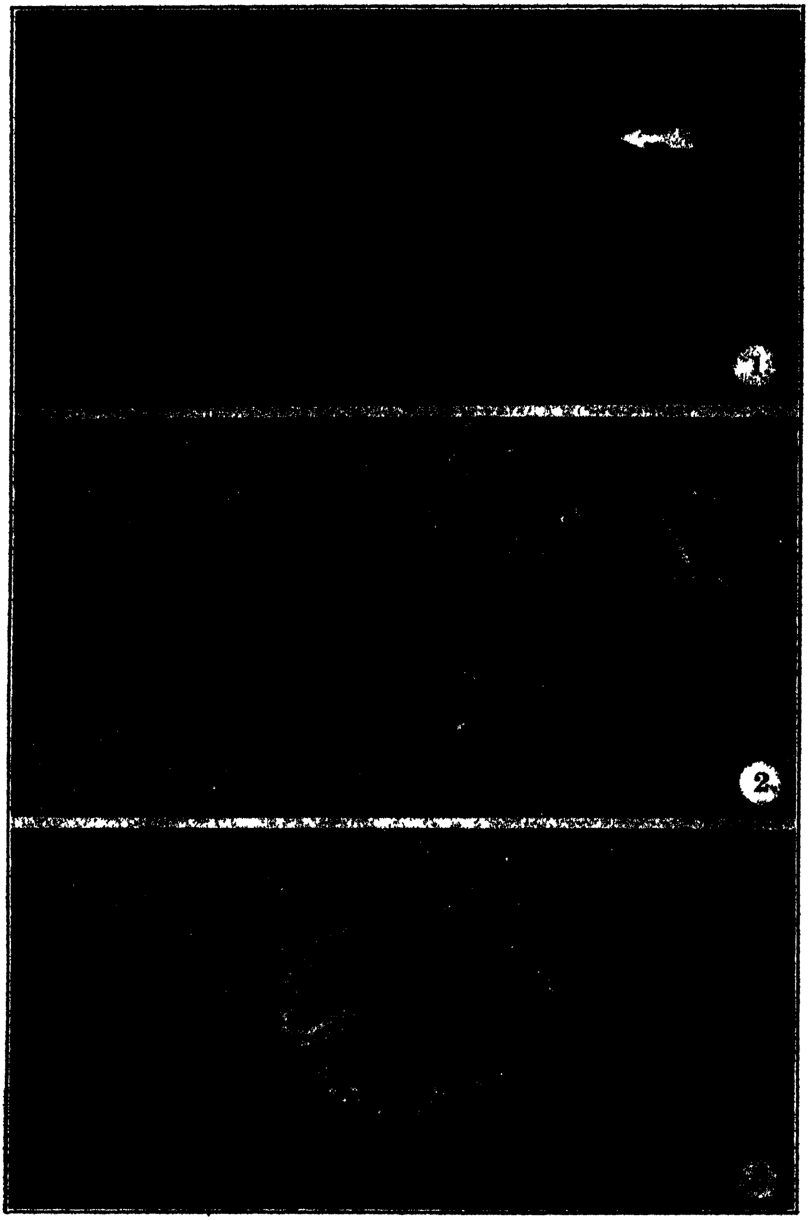


FIG. 1. Wasp excavating nest Arrow points to *Hilarella* fly.
FIG. 2. Paralyzed cutworm at mouth of nest
FIG. 3. Egg of wasp on paralyzed cutworm.

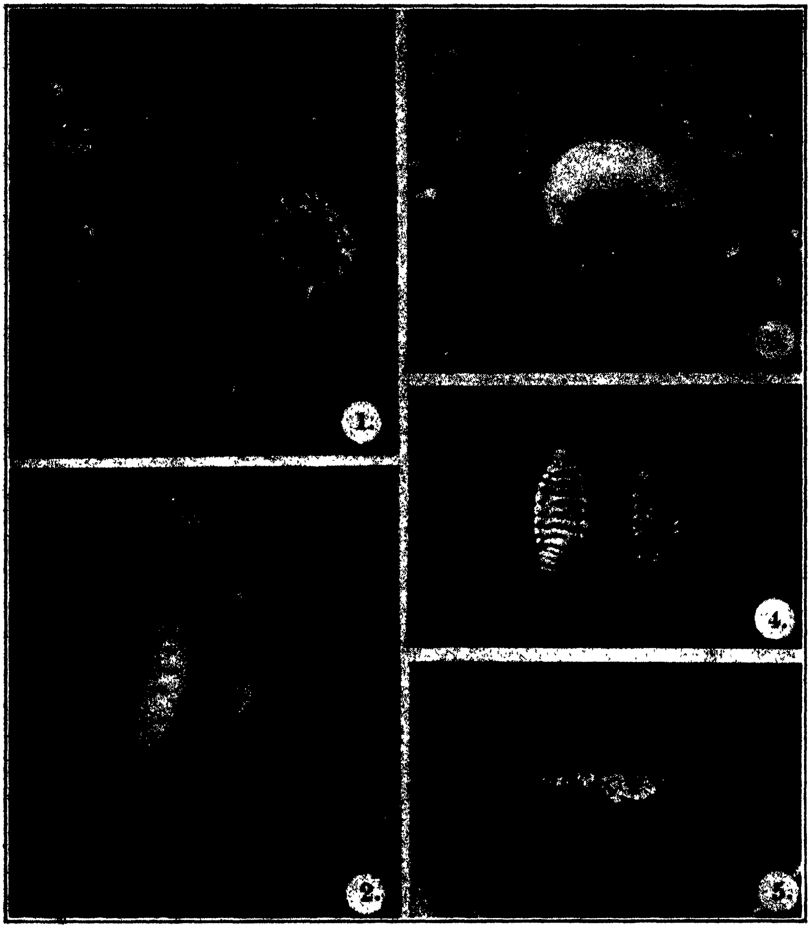


Fig. 1. Young larvæ of wasp. Right, two days old; left, four days old.
Fig. 2. The same larvæ six days later. Larva at left nearly full grown; larva at right has worked partially inside cutworm, and subsequently died.
Fig. 3. Full grown wasp larva with remains of cutworm.
Fig. 4. Full grown wasp larvæ ready to spin cocoons.
Fig. 5. Cocoon of wasp.

DESCRIPTIONS OF THREE NEW NORTH AMERICAN ANTS, WITH BIOLOGICAL NOTES.*

M. R. SMITH,
A. & M. College, Mississippi.

At the present time 119 species of ants have been recorded for Mississippi. Of this number 11 species, or 9.1 percent, are new. These new species have been found within the following genera: *Aphaenogaster*, *Stenamma*, *Pheidole*, *Myrmica*, *Leptothorax* and its subgenus *Dichothorax*, and the subgenus *Colobopsis* of the genus *Camponotus*. Although considerable collecting for ants has been done in some sections of the state, there are other sections which have been practically untouched.

An interesting coincidence is that the species of *Myrmica* and *Stenamma* described below are so far the sole representatives in Mississippi of these two genera. The species of *Stenamma* is of more than casual interest since it is the fourth species to be described for North America. The other three species are as follows: *nearcticum*, a western form, which is known only from the male and female phases; *manni*, a Mexican species; and the common *brevicorne* with its various subspecies and varieties. Whether the new species herein described is allied to *nearcticum* or not can only be settled when workers are collected of *nearticum*, or when the male and female phases of *foveolocephala* are found.

The writer is under obligation to Dr. W. M. Wheeler for his opinion concerning the taxonomical status of several of the ants described below.

Myrmicinæ.

Stenamma fovolocephala sp. nov.

Worker.—Length: 3.6–3.9 mm.

Head, excluding mandibles, distinctly longer than broad, with feebly emarginate almost straight posterior border, rounded posterior angles, and gently convex sides. Eyes large, oval, moderately convex, placed at a distance from the base of the mandibles about equal to or slightly surpassing their greatest diameter; each eye with about 7 ommatidia in its greatest diameter. Mandibles well developed, triangular, somewhat flattened dorsally; each with 5 or 6 distinct teeth. Clypeus moderately convex, protuberant and with the usual

*A contribution from the Mississippi Agricultural Experiment Station.

longitudinal keels or carinæ. Frontal area distinct, subtriangular. Antennæ 12-segmented; scapes moderately robust, not attaining the posterior border of the head; funiculus gradually enlarging distally, the last four segments very noticeably so. Prothorax and mesothorax fused together in such a manner that the suture separating them is almost obsolete; viewed laterally the two form a very gently convex, almost straight continuous surface. Mesoepinotal constriction very distinct, rather broad and fairly deep, separating the pro-mesothoracic region from the lower declivous, basal surface of the epinotum. Epinotal spines viewed in lateral profile small, acute, broader than long, directed backward and outward but scarcely upward. Anterior surface of petiole almost vertical, meeting the superior surface in a rounded yet distinct angle, which is almost a right angle. Postpetiolar node longer and more robust than the petiolar node, and rather strongly convex dorsally; viewed from above, it is somewhat subcampanulate in outline. Gaster from above oval, with rather rounded, indistinct, humeral angles.

Mandibles, lateral border of clypeus, frontal area, legs exclusive of the tarsi, declivous surface of the epinotum, and the gaster, more or less smooth and shining. Dorsal surface of the head, excluding the cheeks and anterior borders, foveolate-reticulate. Thorax rather irregularly rugulose; anterior border of the pronotum, and dorsal surfaces of the mesonotum and epinotum with transverse rugulæ; pleuræ of the pro- and metathorax with longitudinal rugulæ; the mesopleuræ foveolate-punctate. Petiole and postpetiole irregularly rugulose-reticulate with finely punctate interspaces.

Pilosity yellowish; moderately abundant, suberect, longest on the clypeus and gaster. Pubescence of same color as the pilosity, covering all parts of the body, but not obscuring the surface.

Very dark brown, closely approaching black; mandibles, clypeus, antennæ, legs, and gaster from posterior border of first segment to apex, yellowish.

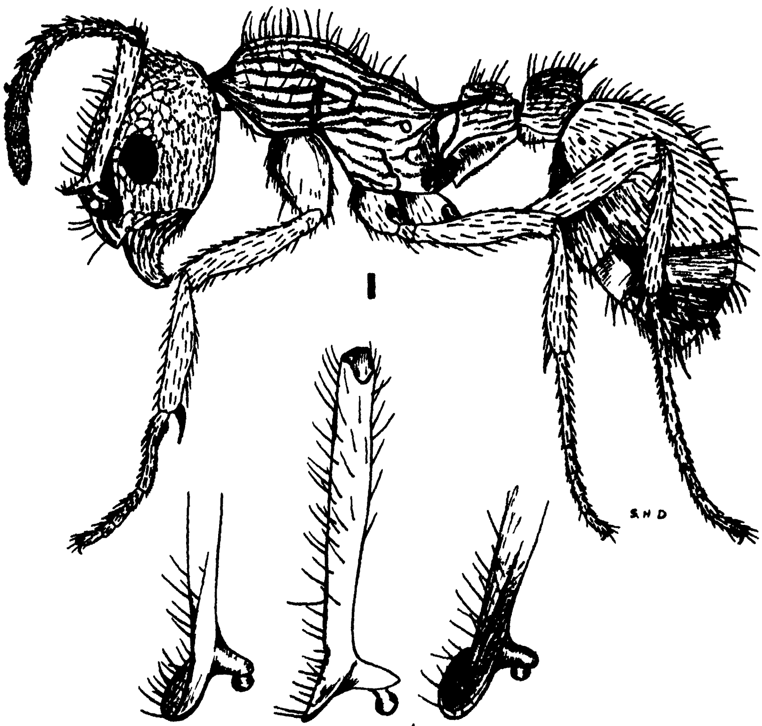
Described from two workers which were collected from sandy soil on the south slope of a thinly wooded hillside two miles south of Ackerman, Mississippi, on February 8, 1930. Cotypes are in the collection of the Department of Entomology of the Mississippi A. & M. College and my collection.

Since no worker phase has been taken of *nearcticum*, a western species, I have not been able to compare my specimens with this species. From *Stenamma brevicorne* and its various forms my specimens differ in the following particulars: (1) larger eyes (which have 6–7 large ommatidia in their greatest diameter); (2) the reticulate-foveolate sculpturing of the head; (3) the transverse rugulæ on the basal surface of the epinotum; (4) the longer and somewhat subcampanulate shaped postpetiole; (5) the deeper body coloration; and (6) by the more highly glabrous surface of the head and thorax.

Myrmica schencki spatulata var. nov.

Worker.—Length: 4.3–4.6 mm.

Head, excluding mandibles, distinctly longer than broad, with rounded posterior border and posterior angles, and convex sides. Eyes prominent, oval, convex, placed at a distance from the mandibles greater than their largest diameter. Mandibles well developed, triangular, with 7 or 8 distinct teeth, the apical 3 the most strongly developed. Clypeus strongly convex; viewed laterally, it is decidedly



2 3 4

FIG. 1. Lateral view of a worker of *Myrmica schencki* var. *spatulata*.
FIGS. 2, 3, 4. Various views of the very large and strikingly spatulate-shaped lobe at the base of the antennal scape of the worker.

(All greatly enlarged. Illustrations by Mrs. S. H. DeBord.)

protuberant. Frontal area triangular, impressed. Antennæ 12-segmented; scapes robust, surpassing the posterior border of the head, each with a very large lobe at its base, which when viewed from above is very large and strikingly spatulate in outline; funiculus each with the last 3 distal segments enlarged but scarcely forming a distinct antennal club. Thorax viewed laterally with a distinct pro-mesonotal suture, the meso-epinotal region strongly impressed dorsally, less so laterally, but not

forming a distinct suture. Epinotal spines long and acute, directed backward and upward, the spines about as long as the face of the declivity of the epinotum. Petiole viewed in lateral profile with flattened superior surface which meets the anterior surface in an almost distinct right angle; below with a short, blunt, anteriorly projecting spine. Post-petiole viewed from the same profile as the petiole, wider dorso-ventrally than antero-posteriorly. Gaster from above oval, the apex with a distinct sting.

Mandibles, clypeus, frontal area, declivity of epinotum, appendages and gaster shining; remainder of body subopaque. Mandibles coarsely and longitudinally striated; clypeus similarly sculptured. Head coarsely rugulose-reticulate with finely punctate interspaces. Thorax and petiole coarsely rugulose, the rugulæ with a distinct longitudinal trend.

Pilosity yellow; coarse, suberect to erect, moderately abundant over all parts of the body, more reclinate on the legs. Pubescence of the same color as the pilosity, closely appressed to the body and so sparse as not to obscure the surface.

Color highly variable in different specimens, in general, yellowish-brown to reddish-brown; appendages lighter, gaster black. The dorsum of the head, thorax, petiole and postpetiole more or less irregularly infuscated and as a rule darker than the rest of the body except the gaster.

Female.—Length: 5.5–6 mm.

Very similar to the worker in all respects but proportionally larger. The head bears three not very distinct ocelli, which are arranged in a nearly equilateral triangle. The sculpturing of the body although similar to that of the worker is much coarser. On the thorax, especially the sides, the rugulæ are regular, almost equi-distant, and have a longitudinal trend.

Pilosity and pubescence hardly distinct from that of the worker.

Color much deeper than that of the worker; dark reddish-brown, with the infuscation on the dorsal surfaces of the body darker, thus giving the ant from above a blackish appearance.

Described from 6 workers and 4 dealated females, all of which were taken from a nest in the soil in a low heavily-wooded area, subject to occasional inundations, 5 miles west of Starkville, Mississippi. Cotypes in the collections of the Department of Entomology of the Mississippi A. & M. College, the collection of Dr. W. M. Wheeler, and my collection.

Formicinæ.

Camponotus (Colobopsis) obliquus sp. nov.

Soldier.—Length: 3.5–3.75 mm.

Head subcylindrical, somewhat longer than broad, with subparallel sides, rounded posterior border, and rounded posterior angles. The anterior truncated surface decidedly oblique, only faintly concave, its

edges carinate along the sides but rounding off above in the clypeal and adjoining regions. Mandibles small, with flattened upper surfaces, each with 4 distinct teeth and a short, toothless, proximal portion. Clypeus on the truncated surface sub-rectangular, somewhat longer than broad, not very noticeably broader above than below; viewed laterally the clypeus is slightly raised above the surface of the cheeks and mandibles. Frontal carinæ far apart, diverging posteriorly for the greater part of their length, then paralleling each other for the remainder of the space. Eyes moderately large, sub-elliptical, gently convex, situated on the posterior half of the head. Antennæ 12-segmented; scapes curved, gradually enlarging distally, and extending a slight distance beyond the posterior corners of the head. Thorax robust. Prothorax and mesothorax when viewed in lateral profile forming a long, gentle arch. Mesoepinotal suture distinct. Base of epinotum cleft; viewed laterally the base appears flattened and slightly shorter than the concave declivous surface, which it meets in a very pronounced angle. Petiole low, convex in front and above, flattened behind, the posterior dorsal border impressed centrally. Gaster oval.

All of the head except that posterior to the eyes opaque, very coarsely reticulate-rugose with punctate interrugal spaces; remainder of head finely shagreened, smooth and shining as is also the thorax, petiole and gaster.

Cheeks and anterior dorsal surface of the head with short, erect, blunt, yellowish hairs. Erect but rather sparse hairs on the vertex of the head, the gastric segments, especially the posterior edges, and a few on the tips of the antennal scapes and femora.

Anterior half of head reddish-brown; posterior half black; funicular segments infuscated. Thorax, legs, and petiole brown. Gaster black; in some specimens the first and second segments are tinged with yellow.

Described from three soldiers which were nesting in a cavity in the husk of a hickory nut, *Caryæ* sp. The nut from which the specimens came was gathered by Mr. J. M. Langston in a low pasture, five miles southwest of Starkville, Mississippi.

One cotype each in the collection of the Department of Entomology of the Mississippi A. & M. College, the collection of Dr. W. M. Wheeler, and my collection.

This species is distinct from any of the other North American *Colobopsis* which I have yet seen. With respect to the shape of the head of the soldier (that is, its parallel sides) it would appear to be allied to *C. impressus*. It differs from the latter species, however, in many respects, notably: (1) its much smaller size, (3.5–3.75 mm.); (2) the much coarser sculpturing of the head; (3) the less concave, truncate surface of the head; and (4) the more rectangular shaped clypeus.

THE IDENTITY OF ZENILLIA BLANDA O. S. AND ZENILLIA VIRILIS A. & W. WITH NOTES ON ZENILLIA BLANDITA COQ. (Diptera, Tachinidæ).

W. F. SELLERS,
Assistant Entomologist, U. S. Bureau of Entomology,
Melrose Highlands, Massachusetts.

Many collections of native insects are reared annually at the Gipsy Moth Laboratory for the purpose of ascertaining to what extent introduced parasites of the gipsy moth (*Porthetria dispar* L.) and the brown-tail moth (*Nygmia phaeorrhoea* Donovan) are attacking native hosts. Owing to this, nearly all the tachinids in the collection of this laboratory are reared

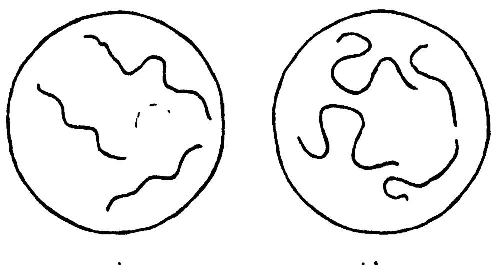


FIG. 1. Diagram of left anal spiracle of puparium of *Zenillia virilis* A. & W.
FIG. 2. Diagram of left anal spiracle of puparium of *Zenillia blanda* O. S.

specimens, and it is possible, in the majority of cases, to associate the puparia with the flies. The detection of certain differences in the puparia of *Zenillia blanda* O. S. (=*Zenillia blanda blanda* O. S. of Aldrich and Webber (*5*)*) and *Zenillia virilis* A. & W. (=*Zenillia blanda virilis* A. & W.) led to a study having for its object the determination of specific differences in the adults themselves.

Figs. 1 and 2 are diagrammatic sketches of the left anal spiracle of the puparium of each species.

From these figures it is readily seen that these puparia are quite distinct on the basis of the arrangement of the spiracular

*Reference is made by number (*italic*) to "Literature Cited," p. 576.

entrances. The puparia of *Zenillia virilis* are easily differentiated by their three rather straight spiracular entrances from those of *Zenillia blanda*, which have four twisted or serpentine spiracular entrances. Greene (*4*) figures a puparium that he calls *Exorista boarmiæ* Coq., but which is now *Zenillia blanda* O. S. He notes that the second spiracular entrance from the bottom is rather long. In the puparia of this species examined in the course of the present study, this entrance did not seem to be constantly longer than the one immediately above it.

In a paper by Aldrich and Webber (*5*) *Zenillia blanda* and *Zenillia virilis* were considered merely subspecific, as only the males could be separated. Specimens of this sex are readily distinguished by the presence or absence of pollen on the third and fourth abdominal sternites. It was, therefore, with the object of attempting to separate the females that a study was made of a series of female specimens associated with puparia. A very constant character was discovered, namely, that an inner ventral bristle, called by Parker (*3*) a submesotibial bristle, was present on *blanda* females and lacking on the females of *virilis*. A series of males was next checked for this character and both species were found to lack the bristle in that sex This character has been used by Stein (*6*) and Lundbeck (*7*) in separating the European species of the genus *Carcelia*. It is interesting to note that this bristle is present in both sexes of *Zenillia blandita* Coq., which is mentioned in this paper because of its striking similarity to *blanda* and *virilis*.

All specimens in the collection were arranged and studied according to the hosts from which they were reared to determine if this played a part in defining the limits of variation. While studying these series of males and females associated with puparia, it was noted that there was a certain definite relationship between the number of sternopleural and dorsocentral macrochaetæ in *Zenillia blanda* and *Zenillia virilis*.

KEY.*

With two sternopleural and three postsutural dorsocentral macrochaetæ; apical scutellar bristles normally turned backward. Male abdomen with the third and fourth segments shining brown or black on the venter, contrasting with the pollinose second; inner forceps slender apically,

*Designed to fit in Aldrich and Webber's (*5*) key to the genus Zenillia, couplet 25.

almost straight, ending inwardly at apex with a small tooth, hairy about two-thirds of their entire length. Male and female lacking an inner ventral bristle on the midtibia. . . . . *virilis* Aldrich and Webber

With two sternopleural macrochaetæ and a sternopleural bristle (rarely indistinguishable from the surrounding sternopleural hairs) and four postsutural dorsocentral macrochaetæ; apical scutellar bristles normally turned upward. Male abdomen with the third and fourth segments pollinose on the venter; inner forceps rather thick apically, outwardly with long hair to the last fifth, which is bent at an obtuse angle. Male without and female with an inner ventral bristle on the midtibia, *blanda* Osten Sacken.

With three strong sternopleural and four postsutural dorsocentral macrochaetæ, strong apical scutellar bristles turned backward. Male and female with an inner ventral bristle on the midtibia . . . . . . *blandita* Coquillett.

The characters used in the key to separate these species are not absolutely constant. It was found in the course of a careful study of the specimens involved that in no case did a specimen depart from the characters mentioned below in more than one respect and this in only very few instances.

Fifty-six *Zenillia virilis* adults exhibited the following percentages of variation: 86 per cent had two sternopleurals on each side, 9 per cent had two on one side and three on the other, and 5 per cent had three on each side; 86 per cent had three dorsocentrals on each side, 7 per cent had three on one side and four on the other, and 7 per cent had four on each side. In all the specimens examined the inner ventral midtibial bristle was lacking.

Three hundred and ninety-three *Zenillia blanda* adults exhibited the following percentages of variation: 93 per cent had three sternopleurals on each side, 4 per cent had two on one side and three on the other, 3 per cent had two on each side; 98 per cent had four dorsocentrals on each side, 1 per cent had three on one side and four on the other, and 1 per cent had three on each side; in 96 per cent of the males the inner ventral midtibial bristle was absent, 6 per cent had it present on one side and absent on the other, 8 per cent had it present; 96 per cent of the females had the inner ventral midtibial bristle present, 3 per cent had it present on one side and absent on the other, and in 1 per cent it was absent. Except for a few flies obtained from *Archips cerasivorana* and *A. fervidana*, all the specimens examined had the inner ventral bristle absent on the males and present on the females.

The following two tables were drawn up to show the host relationship in the case of each species.

TABLE I.

Host Relationships of *Zenillia blanda* O. S.

Hosts Producing *Zenillia blanda* O. S.	Number of of Field Collections	Number of Collections Yielding Recoveries	Number of Hosts concerned in Recoveries	Number of Flies or Puparia Obtained in Recoveries	Adults in Collection Associated with Puparia		Adults in Collection not Associated with Puparia	
					♂♂	♀♀	♂♂	♀♀
Archips cerasivorana Fitch	220	18	33 webs	180	26	15	35	24
Archips fervidana Clem	111	45	102 "	304	25	30	75	84
Catocala sp	1	1	14 "	1	......	1	......	......
Ennomos subsignarius Hubn	23	2	1100 "	3	......	......	......	2
**Hydria undulata* L.	136	6	477 "	10	1	2	3	3
Notolophus antiqua L.	124	1	103 "	2	......	1	......	......
Nygmia phaeorrhoea Donovan	......	1	......	1	......	......	......	1
Sphecodina abbotii Swain	67	1	8	1	......	......	1	......
Thyridopteryx ephemerae formis Haw	27	1	191	1	......	......	1	......
**Tortricid* on poplar†	1	1	2	1	......	......	......	......
**Tortricid* on sumac	1	1	52	2	......	......	2	......
TOTAL	......	......	......	......	52	49	117	114
Hosts Producing both *Zenillia blanda* O. S. and *Zenillia virilis* A. & W.								
Cingilia catenaria Drury	46	10	1534	47	12	22	2	......
**Epargyreus tityrus* Fab	159	3	21	3	......	2	......	......
**Hadena turbulenta* Hubn	14	5	1374	14	4	4	......	1
Hyphantria cunea Drury	381	16	2003 and 122 webs	24	......	3	4	5
Vanessa atalanta L.	97	1	218	2	......	......	1	1
TOTAL	......	......	......	......	16	31	7	7
GRAND TOTAL	......	......	......	......	68	80	124	121

*Overwintering hosts.

†Although the fly recovered from tortricid on poplar is not in the collection, it had been identified as *Exorista boarmiæ* Coq. and undoubtedly belongs here.

TABLE II.

Host Relationships of *Zenillia virilis* A. and W.

Hosts Producing *Zenillia virilis* A. & W.	Number of Field Collections	Number of Collections Yielding Recoveries	Number of Hosts Concerned in Recoveries	Number of Flies or Puparia Obtained in Recoveries	Adults in Collection Associated with Puparia		Adults in Collection not Associated with Puparia	
					♂♂	♀♀	♂♂	♀♀
Arsilonche albovenosa Goeze	28	1	1	1	......	1	......	......
Acronycta dactylina Grote	48	1	7	1	......	1	......	......
Acronycta distans Grote	88	1	6	4	1	2	......	......
Acronycta grisea Walk	17	1	1	1	......	......	1	......
Acronycta leporina L., *chionochroa* Hamp	28	10	26	24	8	9	......	......
Callosamia promethea Drury	124	2	500	6	......	1	3	1
**Ceratomia catalpæ* B. d. v.†	30	1	300	3	1	2	......	......
**Anacamptodes ephyraria* Walk	1	1	18	1	1	......	......	......
Gluphisia septentrionalis Walk	15	6	32	7	3	2	......	......
Mamestra ligitima Grote	61	1	1	1	1	......	......	......
Melalopha albosigma Fitch	7	1	1	1	......	1	......	......
Melalopha strigosa Walk	8	1	1	1	......	1	......	......
**Phigalia titea* Cram	69	1	151	6	2	......	......	......
**Porthetria dispar* L	......	10	......	10	2	......	2	1
TOTAL	......	......	......	......	19	20	6	2
Hosts Producing Both *Zenillia virilis* A. & W. and *Zenillia blanda* O. S.								
**Cingilia catenaria* Drury	46	1	129	8	2	1	......	......
Epargyreus tityrus Fab	159	1	54	1	1	......	......	......
Hadena turbulenta Hubn	14	2	685	2	......	1	1	......
Hyphantria cunea Drury	381	2	80 webs	2	......	......	1	1
**Vanessa atalanta* L.	97	1	218	1	......	......	......	1
TOTAL	......	......	......	......	3	2	2	2
GRAND TOTAL	......	......	......	......	22	22	8	4

*Summer hosts. †In this case it was the first generation of *Ceratomia catalpæ* B. d. v.

Larvæ of both these species normally emerge from the host pupa, but occasionally form their puparia within the host. Individual records show further that both forms hibernate as maggots in the host pupa. In the cases considered in this paper, if parasitic on hosts producing adults in the same season, both parasites completed their development that season; but if parasitic on hosts that pass the winter in the pupal stage and emerge the following spring or summer, the flies likewise did not emerge until the following spring. The only exception to this was a fly reared from *Sphecodina abbotii* Swain. and this may have been because the host apparently passes the winter as an imago within the pupal case. *Zenillia virilis* and *Zenillia blanda* were found to have five hosts in common, and in six instances both species were recovered from the same collection. The adults of the summer generation emerged from the middle of July until fall, and those coming from the overwintering hosts issued from spring until the early part of August.

The *Zenillia blanda* adults noted in Table I have been recovered from 74 localities in the following states: Connecticut (2), Maine (7), Massachusetts (37), New Hampshire (2), New Jersey (9), New York (5), Pennsylvania (1) and Rhode Island (11); whereas the *Zenillia virilis* adults noted in Table II have been recovered from 31 localities in the following states: Connecticut (4), Maine (9), Massachusetts (9), New Hampshire (1), New Jersey (6), New York (1), and Rhode Island (1). Published distribution records by Aldrich and Webber (*5*) of specimens of *blanda* from other than those places already mentioned are as follows: Maryland, Virginia, North Carolina, Kansas, Arkansas, New Mexico, Arizona, Colorado, Florida, Cuba and Peru. Owing to possible misidentification, some of these records may concern *virilis*. The locality records of Kansas and the Federal District, Mexico, given by Aldrich and Webber for *virilis* undoubtedly refer to this species, since only male specimens were concerned.

Additional Notes on *Zenillia blanda* O. S.

The following material at the Museum of Comparative Zoology, Cambridge, Massachusetts, was examined: Osten Sacken's type, one female specimen labeled as bred from *Thanaos brizo*, and four specimens in the C. W. Johnson collection labeled *Exorista boarmiæ*. Osten Sacken's type was labeled "25° from the S. H. Scudder Collection,"

"Type," "bred from *Cynthia cardui J. rufipes.*" The fly, a male, had two strong and one weak sternopleural bristles; four dorsocentral macrochaetæ; apical scutellar bristles weak and turned up; third and fourth sternite pollinose; midtibia with two posterior, one outer, and no inner bristles. The anal spiracles of the puparium which was pinned with the type specimen, are like those figured by Greene (*4*) under the name of *Exorista boarmiæ* and in this paper under the name of *Zenillia blanda.* The specimen bred from *Thanaos brizo* had two strong sternopleural bristles on one side and two strong and one weak on the other side; four dorsocentral macrochaetæ; apical scutellar bristles turned up; inner ventral bristle present. A number of field collected specimens were all *blanda* except one female, which was *virilis.*

At the Boston Society of Natural History among the several *Zenillia blanda* specimens as now rearranged is one male labeled "*Ex Depressaria heracliana,* Salisbury Cove, Maine, VII-6-23."

Howard and Fiske (*2*) mentioned a specimen of *Exorista boarmiæ* Coq. as having been reared from a collection of brown-tail moth larvæ; this is the same specimen listed in Table I as being from that host.

Owing to the confusion of female characters in *blanda* and *virilis* as treated by Aldrich and Webber (*5*) their host list is not cited in this paper.

ADDITIONAL NOTES ON *Zenillia virilis* A. and W.

The sternopleural and dorsocentral characters used by Coquillett (*1*) for *Exorista blanda* are those given for *Zenillia virilis* in the key in this paper. The examination of the type of *blanda* has proven Coquillett's conception of this species to be erroneous. Undoubtedly there has been much misidentification of *blanda* and *virilis* as now known, where Coquillett's classification has been followed. Because of this fact the three specimens recorded by Howard and Fiske ((*2*) *Tables IV and V*) as *Exorista blanda* are probably to be regarded as *virilis.* These specimens are distinct from the five flies from *Porthetria dispar* listed in Table II of the present paper, which were originally identified as *blanda* by the same workers.

In the material at the Museum of Comparative Zoology, Cambridge, Massachusetts, one female *Zenillia virilis* was discovered among the *Zenillia blanda* material. Two specimens, one male and one female, determined as *Zenillia (?)blandita* proved to be *virilis.* In the Johnson Collection three specimens labelled as *Exorista blanda* were found to be *virilis.*

In the collection at the Boston Society of Natural History several specimens of *Zenillia virilis* were found in the *Zenillia blanda* and the *Zenillia blandita* material.

Aldrich and Webber (*5*) record one male from *Papaipema harrisii* Grote and one male from *Ennomos subsignarius* Hubn. (the latter reared at the Gipsy Moth Laboratory).

NOTES ON MATERIAL OF *Zenillia blandita* Coq. EXAMINED.

The following specimens were studied: One female determined by Webber, at the Gipsy Moth Laboratory, labeled No. Saugus, Mass.; one male determined by Aldrich, in the Johnson Collection, labeled Washington, D. C.; and one female in collection at the Boston Society of Natural History, labeled Auburndale, Mass. These specimens agree with the characters given in the key. Despite the distinctive characters and large size of this fly, it is well named *blandita* because of its close resemblance to *Zenillia blanda.* Aldrich and Webber (*5*) give as the only host *Sarrothripus revayanus* Scop.

LITERATURE CITED.

1. **Coquillett, D. W.** Revision of the Tachinidae of America, North of Mexico. U. S. D. A., Div. of Ent., Technical Series, No. 7, 1897.
2. **Howard, L. O., and Fiske, W. F.** U. S. D. A., Bur. of Ent., Bul. 91, 1911.
3. **Parker, R. R.** Sarcophagidae of New England. Proceedings Boston Society of Natural History, 1914.
4. **Greene, Charles T.** Proc. of the U. S. Nat. Mus., Vol. 60, Art. 10, 1921, pp. 1–39, pls. 1–20.
5. **Aldrich, J. M., and Webber, R. T.** Proc. of the U. S. Nat. Mus., Vol. 63, Art. 17, 1924, pp. 1–90.
6. **Stein, P.** Die verbreitetsten Tachiniden Mitteleuropas nach ihren Gattungen und Arten, Archiv fur Naturgeschichte, A. 6, 1924.
7. **Lundbeck, W.** Diptera Danica, Part VII, Platypezidae, Tachinidae, 1927.

MANUAL FOR THE STUDY OF INSECTS, by JOHN HENRY COMSTOCK, ANNA BOTSFORD COMSTOCK and GLENN W. HERRICK; pp. 1–401, colored frontispiece and 633 figures. The Comstock Publishing Company, Ithaca, N. Y.

The reappearance of this classic in its new and completely revised form will bring pleasant memories to all American entomologists of the older generation as it opened to many the first door to an entrancing world. It is pleasing that the authors have retained its previous form, even to the color and material of the binding, though the volume has been reduced to half of its former thickness by the use of thinner paper. The younger entomologists will be interested to know that it took ten years to complete, that much of it was written in the early morning between the hours of four and eight o'clock, that the illustrations of insects are wood cuts engraved during this period by Mrs. Comstock, which was an equally arduous task. The present edition, the nineteenth, is completely revised, a work started by Professor Comstock and completed by Professor Herrick. After thirty-six years the Manual still ranks among the best of beginning texts because of the very great amount of able and painstaking work put into it by Professor and Mrs. Comstock.

C. H. K.

THE BIONOMICS OF DIBRACHOIDES DYNASTES (FOERSTER), A PARASITE OF THE ALFALFA WEEVIL.

H. D. SMITH,*
Assistant Entomologist, Cereal and Forage Insect Investigations, Bureau of Entomology, United States Department of Agriculture, Hyères, France.

INTRODUCTION

The hymenopterous parasite, *Dibrachoides dynastes* (Foerster,) dealt with in this paper, is considered to be the most important prepupal and pupal parasite of the alfalfa weevil, *Phytonomus posticus* (Gyll.), a species of weevil accidentally introduced into the United States, where it has proven extremely injurious to alfalfa in Utah, Idaho, and neighboring States.

During the course of the parasite-collection work carried on at the European Parasite Laboratory of the U. S. Bureau of Entomology at Hyères, France, to procure parasites for shipment to the United States, it was found more feasible to rear this parasite in quantities in the laboratory than to collect it in the field. To accomplish this, many thousands of full-grown weevil larvæ were collected in the latter part of April by sweeping, brought into the laboratory, and allowed to spin their cocoons, after which they were placed in cold storage at a temperature of from 10° to 13° C. as a constant source of supply. Through the use of this material and one fertilized female parasite the greater part of the following notes was obtained.

LIFE CYCLE OF THE HOST IN THE VICINITY OF HYÈRES, FRANCE

The eggs of *Phytonomus posticus* are found, from January to May, inclusive, in the dry or green alfalfa stems. The first larvæ make their appearance in the early part of March and after feeding inside the stalk for several days they crawl to the leaf buds and leaves where they complete their feeding. About the middle of April the larvæ finish feeding and drop to

*The writer offers grateful acknowledgment to Dr. H. L. Parker for his advice and helpful criticisms of the manuscript and to A. B. Gahan for furnishing data on the synonymy.

the ground where they spin their cocoons. These are white, more or less oval, coarsely woven, and very flexible, and are usually found attached to fragments of dead leaves or rubbish on the ground. The adults emerge from these early cocoons the latter part of April and remain in diapause until the following December.

The larvæ of the main brood appear about the latter part of March and form their cocoons the first part of May, the adults emerging a week or two later and remaining in diapause as do those of the early brood.

Occasionally a few scattered weevil larvæ may be found in the field during the summer and fall.

SYNONYMY OF THE PARASITE

The earliest definite reference to this species of parasite in literature appeared in 1841 when Foerster (3) described the female under the name *Pteromalus dynastes.*

In 1912 Webster (13) made the first biological notes on this species but was unable to determine it.

Finally in 1913 Kurdjumoff (5) created the genus *Dibrachoides* and designated *Pteromalus dynastes* Foerster as the type. He also listed *Pteromalus communis* (Nees) as a synonym but questioned it.

DISTRIBUTION

The first specimen of this species was recorded from Germany by Foerster (3) in 1841. In 1911 W. F. Fiske collected a large number near Naples, Italy. A few years later Kurdjumoff (5) collected some at Poltava, Ukraine, Russia. Since then it has been found by T. R. Chamberlin (1) at Hyères, Tournon, and Lons-le-Saunier in France. It was introduced into the United States and was artificially colonized in Utah in 1911 (13) from the Salt Lake City Laboratory. L. P. Rockwood later (10) recorded it from the State of Washington.

ECONOMIC IMPORTANCE

No extensive inquiry has been made regarding the amount of parasitism existing in the field but in one heavily infested locality near Hyères, in 1929, it was 5 per cent, and the few records of previous years show that this is about the maximum

rate of parasitism. As the experiments show that this parasite winters over as an adult, with probable high mortality, its importance as a check on the host may be somewhat lessened. Up to the present, however, it appears to have the highest percentage of parasitism and the widest distribution of any of the parasites in Europe found attacking the cocoon stage of the weevil.

LIFE HISTORY AND HABITS

EMERGENCE

After the change to the adult stage both sexes remain quiescent in the host cocoon for a period of from 3 to 20 hours depending on the temperature. Even if the cocoon has a hole large enough to permit their escape they do not issue until this "resting period" is terminated. Eventually they begin the search for openings and if none is found they cut a few strands of the cocoon with their mandibles. As they are intermittently searching for openings and cutting the network the hole made by the first issuing parasite may serve as an exit for the others, or if this hole is not discovered by them each may make its own. The males are usually the first to emerge.

From 100 pupal hosts parasitized in the laboratory and kept at temperatures corresponding to those in the field 370 adult parasites emerged, making an average of 3.7 per host. The average emergence per prepupal host was not determined but as fewer eggs are laid on this stage than on the pupal host the average would be somewhat less.

MATING

The males are sexually active just previous to or immediately after their emergence from the host cocoon but the females are not so until the second day. Copulation takes place after emergence from the cocoon, though sometimes the male manifests his sexual activities before this time by a process of preliminary "courtship" maneuvers. The female, however, does not permit actual copulation. The males do not perceive readily the difference between sexes as when males alone were placed in containers they would go through a part of the preliminary maneuvers with other males, often mounting upon their backs, from which they are quickly thrown.

The male does not usually become aware of the female's presence until he touches her with his antennæ, whereupon he becomes greatly excited. His antennæ are directed towards the female and vibrate rapidly as his body sways from side to side. He then attempts to mount, usually from the rear. The female is constantly on the move when harassed by the male but stops as he climbs upon her back. In this position with his legs gripping her thorax the male places his head between the antennæ of the female and strokes them with his own, and also occasionally with his mouthparts. He then stops the stroking, raises his body slightly, and flutters his wings very rapidly. These preliminary movements may be practiced one or several times before an actual attempt at copulation is made; when, however, they are completed the male moves backwards and curves his abdomen under that of the female and attempts the act of copulation. If the female desires the act she remains quiet and allows the contact to be established; if not, she lowers her abdomen and moves away, thus causing the male to fall off. At other times the female may raise her wings to loosen his hold or merely lower her ovipositor so that he can not reach the genital opening. Usually many repetitions of these preliminary movements are necessary before copulation takes place. The length of time required for coition is from 9 to 15 seconds. When copulation is terminated the male moves away to rest for a short time and returns to attempt it again.

The female apparently permits only one copulation during her life, though unable to prevent the male from indulging in the courting preliminaries for short periods at various times. The sexes were found to mate very readily at any time of the day in vials 8 by 1.5 cm. in size, at temperatures from 18° to 28° C. and somewhat more quickly if left apart for about 2 days after emergence.

OVIPOSITION

Oviposition may begin on the second day after emergence but generally it does not commence until the third; it *never* begins, however, until after the female has located, stung, and fed upon the host, a process which is described under "Methods of Feeding."

Egg laying takes place at any hour of the day or night at temperatures between 18° and 30° C., the optimum being about 23° C.

The preferred stage of the host seems to be the prepupal and after that the pupal.

The female crawls over the coarsely woven host cocoon, feeling through the network with her antennæ for the location of the already paralyzed host. If she does not find it in this manner she will thrust her ovipositor into the cocoon and locate it with that organ. She spends from 5 mintues to several hours with occasional rests feeling over the host with the tip of the ovipositor and pushing and pulling it into a suitable position.

When ovipositing upon a prepupa, the female takes a position with her ovipositor thrust through the network of the host cocoon and resting between the segments of the thorax. An egg, enveloped in white mucous liquid, moves down the inside of the ovipositor until it is entirely free from the genital orifice, suddenly appears on the outside of the ovipositor, and is pushed towards the host. When it reaches the tip of the ovipositor it does not immediately slide off but sticks there momentarily and the pressure of the stylets behind pushes it into a round ball which snaps off onto the host, quickly assuming its original shape. Usually several eggs are deposited in this manner without change of position but occasionally the operation may terminate after only one is laid. The female then crawls to another part of the cocoon and either tries to place these eggs in a more favorable location by manipulating them with her ovipositor or lays others. After laying 3 to 5 eggs she usually feeds, either on the host just paralyzed or on a new one. In the majority of cases the eggs are placed together in an irregularly shaped group on the ventral surface of the thorax.

When laying eggs upon a pupal host the operation differs slightly. The female maneuvers around the host until her ovipositor rests between one of the wing pads and the abdomen, and the eggs are pushed under the wing pads as far as possible. If 3 or 4 eggs are laid under one wing pad the first laid are often pushed under so far that they come out from under the other edge and lie in an exposed heap between the wing pads. In other respects the laying procedure is the same.

Very often the female is either unable to release the egg or else she can not find a suitable location and it is wiped off on the cocoon as she withdraws her ovipositor. If the egg projects above the cocoon she pushes it inside with her mouthparts or

the tip of her abdomen and later attempts to place it on the host. Eggs are occasionally found on the cast larval skin. She is not usually successful in placing these eggs on the host and many of them dry up and fail to hatch while the larvæ which hatch from the others die before reaching the host.

OVIPOSITION PERIOD

The oviposition period extends over the greater part of the life of the parasite. Beginning two days after emergence it continues until within a few days before death. If the female is presented with an abundance of suitable host material, at from 20° to 30° C., the oviposition period lasts from two weeks to one month.

NUMBER OF EGGS LAID

The maximum number of eggs laid by a single female was 122 and these were laid a few every day for a period of four weeks. The maximum number of eggs found on one host (a pupa) was 16 and the minimum 1. The average number per host for 50 individuals observed was 3 on the prepupa and 4 on the pupa. The maximum in 24 hours at 23° C. was 26 on 9 prepupæ and the average was 8 on 3 prepupæ. At 18° C. the maximum daily rate was 11 on 2 prepupæ and the average 4.

THE EGG

The egg (Pl. I, fig. 1) is translucent whitish in color. The chorion is thin and elastic with a smooth, shining surface. It is simple in form, slightly arched, and has a number of very fine ridges irregularly placed and running more or less longitudinally. The average length is 0 42 mm. and the average width 0.16 mm.

INCUBATION

At temperatures ranging from 25° to 30° C. the period of incubation ranges from one and one half to two days, depending upon the location of the egg on the host. The developing embryo can be seen near the center of the egg as a cloudy white oval body. When the larva is fully formed the chorion is ruptured at the anterior end and the larva emerges.

Moisture plays a very important part in the incubation of the egg, as it was observed that when the eggs are placed under the wing pads or in the crevices between the segments of the prepupa, where it is more humid, they hatch in a minimum of

time with practically no mortality, whereas when they are placed on the exposed surface some of them dry up and fail to hatch and the incubation period of the others is slightly increased.

FIRST INSTAR

The newly emerged larva (Pl. I, Fig. 2) is about 0.45 mm. long and 0.18 mm. wide. It is widest at the thorax and tapers gradually to the caudal end. It is translucent whitish in color, smooth and shining, and consists of a head and the usual 13 segments.

The head (Pl. I, Fig. 3) is white, slightly more chitinized than the body, and bears a pair of small fleshy conical antennæ. Around the mouth are 3 pairs of small sensorial spines, one pair anterior to the labrum, one pair laterad of the mandibles, and one pair laterad of the labium. The labrum bears 4 pairs of sensorial organs in the form of circles. The mandibles (Pl. I, Fig. 4, A) are 0.015 mm. long, arched, sharply pointed, testaceous in color, with 10 to 15 minute teeth on the inner margin. Each mandible is supported at its base by two chitinized arms or mandibular "apophyses" (after Parker) (7), the superior one extending to the interior only a short distance and the inferior one uniting with that of the opposite side to form a continuous support. The labium, which is a fold of soft tegument below the mouth, bears 6 pairs of small circular sensorial organs. Each segment of the thorax has 3 pairs of small sensorial spines and each abdominal segment 2 pairs; these spines are situated as follows: two dorso-lateral and two lateral rows extending from the first thoracic to the 10th abdominal inclusive, and two ventral rows on the thorax with one spine on each segment. The anal segment is not bilobed. Extending around the body on the anterior border of each segment there is a narrow band of very minute tegumentary spines visible only under the highest magnifications.

The respiratory system (Pl. I, Fig. 2) is composed of a main longitudinal trunk on each side of the body united anteriorly in the first thoracic and posteriorly in the eighth abdominal segment by transverse commissures. There are 4 pairs of open spiracles, a pair on the second thoracic segment and each of the first three abdominal segments. The dorsal branches in each segment arise from the lower part of the spiracular branch, and not from the main longitudinal trunk, as is the case in most chalcids heretofore studied. The ventral branches arise from the main longitudinal trunk near the bases of the spiracular branches.

SECOND INSTAR

The average larval length is 0.62 mm. and the average width 0.29 mm. The inferior mandibular apophyses are not united by a transverse chitinous arm under the mouth as was the case in the first stage but are separated like the superior pair. The mandibles (Pl. I, Fig. 4, B) are approximately the same size as in the first instar but less chitinized and the teeth are more prominent. Their shape has changed entirely

and resembles that of the mature larva, being broader at the base and not hooked at the tip. The sensory spines and antennæ are much smaller than in the preceding stage but their arrangement is the same. There is an additional pair of short sensory spines between the antennæ. The labium and maxillæ are fused and have 4 small sensory spines on each side together with 4 circular sensory organs, one of which is elevated slightly above the surface. The body has lost the band of minute spines around each segment. There are 9 pairs of spiracles present, 1 pair to each of the last 2 thoracic and first 7 abdominal segments. The color is light brown.

THIRD INSTAR

The larva averages 1.25 mm. by 0.46 mm. The color is the same as in the previous instar. The spines and antennæ are slightly larger. The mandibles are longer and the teeth somewhat more prominent.

FOURTH INSTAR

The larva averages 1.74 mm. by 0.70 mm. The color is pink or clay. The spines, antennæ, and dentate mandibles are all slightly larger.

FIFTH INSTAR

The average length of the fifth instar or mature larva (Pl. I, Fig. 6) is 2.83 mm. and the average width 0.95 mm. It is of a typical chalcidoid form, somewhat spindle shaped and slightly curved. It is usually pink in color owing to the distended stomach containing the red fluid of the host's Malpighian tubes. If these tubes are untouched it is a clay color arising from the fluids in the body cavity of the host. After leaving the host to cast its meconium it is always gray. The cuticle appears smooth and shining under low magnification. The sensory spines of the body and their arrangement are the same as in the first instar.

The head (Pl. I, Fig. 5) is very smooth on its upper surface and sides and bears a pair of fleshy conical antennæ. The sensory organs of the head are arranged the same but are larger than in the three preceding instars. There are two additional pairs of organs in the form of circles, one pair laterad of the labrum and the other between the labrum and antennæ. The labrum has 5 pairs of circular organs. The mandibles (Pl. I, Fig. 4, C) are 0.0526 mm. in length, with the superior margin nearly straight and the inferior margin slightly curved, and bear from 10 to 15 small teeth each.

The respiratory system (Pl. I, Fig. 6) is practically the same as in the second instar except for a general increase in the number and length of the branches. There are also rudiments of a tenth spiracle on the eighth abdominal segment but it is not open to the exterior.

The digestive system consists of the mouth, a short, slightly enlarged pharynx, a somewhat shorter and narrower oesophagus, a very large stomach, and a short hind intestine. There are two salivary glands, one on each side of the stomach extending from near the posterior

end of the stomach to the floor of the mouth, and 3 very short Malpighian tubes attached to the anterior end of the hind intestine.

The muscular system is composed of 4 groups of longitudinal muscles, with 5 muscles in each, 2 dorso-lateral and 2 ventro-lateral. There are also 10 oblique muscles on each side from the third to the twelfth segment, each crossing 3 segments and extending anteriorly in a dorso-ventral direction from just laterad of the lower dorso-lateral muscles to a point beyond the ventro-lateral group.

PREPUPA

When the larva becomes full grown it leaves the host and crawls about in the cocoon for a few hours. After coming to rest it commences the prepupal stage by expelling all the material in the intestines. During this operation a slight constriction forms between the thoracic and abdominal segments and the head is more transparent. The color is light cream.

PUPA

Male: Length 2.10 mm., width 0.75 mm. Female (Pl. I, Fig. 7): Length 2.70 mm., width 0.82 mm.

The pupa when first formed is entirely white. At 28° C. the color changes within a few hours to pale yellowish brown. In about 3 days at this temperature the mouthparts turn brown and the ocelli and eyes become reddish. A day later the head becomes black. On the fifth day, first the thorax and then the abdomen turn black and after a few hours the adult emerges. The males may be easily distinguished at any time from the females by the fact that in the males the distance between the last pair of legs and the caudal end is much shorter. When the pupæ are mature the male is further distinguished by the light yellow spot near the anterior portion of the abdomen. The males are usually smaller than the females.

ADULT

The adult female is about 3 mm. long. The head and thorax are dull metallic green. The antenna is dark brown, except the scape, which is testaceous. The legs are testaceous, except the coxæ, which are concolorous with the thorax, and the apical tarsal joints, which are dark brown. The abdomen is brownish-black with bronzy to brassy green metallic reflections. The wings are hyaline.

The male is about 2.3 mm. long. The head and thorax are bright metallic blue-green. The scape is very pale testaceous and the club and base of pedicle are fuscous. The rest of the antenna is testaceous. The legs are pale testaceous, except the coxæ, which are concolorous with the thorax, and the apical tarsal joints, which are dark brown. The abdomen is dark brown with bluish green reflections and a large yellow more or less rectangular area near the base.

This species may be readily distinguished from the other pteromalid parasites of the alfalfa weevil by its large size and its excavated occiput.

DEVELOPMENT AT DIFFERENT TEMPERATURES

An experiment was carried out to determine the period of development of each of the immature stages of the parasite and these are summarized in Table I.

When full grown larvæ were kept at temperatures of from 8° to 13° C. many expelled some or all of their meconium but failed to reach the pupal stage. At lower temperatures the larvæ died in about two weeks without any change other than

TABLE I.

Rate of Development of Immature Stages of *Dibrachoides dynastes* (Foerst.)

AVERAGE OF 25 INDIVIDUALS.

Temperature and Humidity	Length of Egg Stage	Length of Larval Stage	Length of Prepupal Stage	Length of Pupal Stage	Period from Egg to Adult	Time in Cocoon
25°–30° C. 40%–60%	1¾ days	5 days	8 hours	5 days	12 days 2 hours	9 hours
18° C. 60%–80%	3½ days	9 days	1½ days	11 days	25 days	20 hours
8°–13° C. 60%–80%			9 days			9 days

an occasional discharge of the meconium. Pupæ placed at temperatures of from 8° to 13° C. changed very slightly, rarely becoming black. The body turned light brown and the eyes pink and remained thus as long as they were at these temperatures or until they died. If kept under these conditions over 4 or 5 weeks their vitality was greatly lowered, as only a few emerged when gradually exposed to warm temperatures and these lived only a short time.

LARVAL FEEDING AND GROWTH

If the egg is in contact with the body of the host, the larva on hatching begins at once to feed at that point and usually remains there until through feeding. If laid away from the host, either on the cast larval skin or the cocoon, it proceeds to search for the host but usually dies before reaching it. After the feeding is completed the larva leaves the host and crawls about in the cocoon for a day or so before expelling its meconium. When there are 5 larvæ on one host, the resulting

adults are usually smaller owing to the lack of available food and they reach maturity sooner than when there are but 3 or 4 larvæ to a host. These latter numbers appear to be the optimum from the standpoint of the parasite.

HABITS OF THE ADULT

The females are somewhat negatively phototropic, especially when kept over several months without hosts. When placed in a large vial, darkened at one end, they usually crawl to the dark end and remain there more or less motionless. If a broken host cocoon is placed in the vial, whether darkened or not, the female will crawl inside of it and remain there for several days. The males seek the light more eagerly and are more active than the females.

At all temperatures from 0° to 32° C. both sexes are more or less active, as is noticed by their occasional change in position from day to day. Some females at 0° C., however, did not move and appeared dead but soon revived when brought into a warm room. Above 30° C. they were most active and the females did not oviposit.

METHODS OF FEEDING

The adult male and female will feed on honey or sugar solution but the preferred food of the female is the body fluids of the host.

The male does not feed from this source.

When about to feed on the host the female examines the cocoon very carefully with her antennæ. She then thrusts her ovipositor inside of it and very cautiously stings the host causing it to twist and turn spasmodically for several minutes. After that she merely holds her organ inside waiting for the host to roll against it. Sometimes she is able to keep her ovipositor in the host for several seconds and in that case it will writhe violently for a long time, and during this period she rests on the cocoon with her ovipositor withdrawn. She stings the host from 3 to 100 times before it is completely paralyzed, taking from 10 minutes to 8 hours. On the whole it requires less time to paralyze the prepupa than the pupa and this fact may account somewhat for the female's preference of the former as host.

DEVELOPMENT AT DIFFERENT TEMPERATURES

An experiment was carried out to determine the period of development of each of the immature stages of the parasite and these are summarized in Table I.

When full grown larvæ were kept at temperatures of from 8° to 13° C. many expelled some or all of their meconium but failed to reach the pupal stage. At lower temperatures the larvæ died in about two weeks without any change other than an occasional discharge of the meconium. Pupæ placed at temperatures of from 8° to 13° C. changed very slightly, rarely becoming black. The body turned light brown and the eyes pink and remained thus as long as they were at these temperatures or until they died. If kept under these conditions over 4 or 5 weeks their vitality was greatly lowered, as only a few emerged when gradually exposed to warm temperatures and these lived only a short time.

TABLE I.

Rate of Development of Immature Stages of *Dibrachoides dynastes* (Foerst.)

AVERAGE OF 25 INDIVIDUALS.

Temperature and Humidity	Length of Egg Stage	Length of Larval Stage	Length of Prepupal Stage	Length of Pupal Stage	Period from Egg to Adult	Time in Cocoon
25°-30° C. 40%-60%	1¾ days	5 days	8 hours	5 days	12 days 2 hours	9 hours
18° C. 60%-80%	3½ days	9 days	1½ days	11 days	25 days	20 hours
8°-13° C. 60%-80%			9 days			9 days

LARVAL FEEDING AND GROWTH

If the egg is in contact with the body of the host, the larva on hatching begins at once to feed at that point and usually remains there until through feeding. If laid away from the host, either on the cast larval skin or the cocoon, it proceeds to search for the host but usually dies before reaching it. After the feeding is completed the larva leaves the host and crawls about in the cocoon for a day or so before expelling its meconium. When there are 5 larvæ on one host, the resulting

adults are usually smaller owing to the lack of available food and they reach maturity sooner than when there are but 3 or 4 larvæ to a host. These latter numbers appear to be the optimum from the standpoint of the parasite.

HABITS OF THE ADULT

The females are somewhat negatively phototropic, especially when kept over several months without hosts. When placed in a large vial, darkened at one end, they usually crawl to the dark end and remain there more or less motionless. If a broken host cocoon is placed in the vial, whether darkened or not, the female will crawl inside of it and remain there for several days. The males seek the light more eagerly and are more active than the females.

At all temperatures from 0° to 32° C. both sexes are more or less active, as is noticed by their occasional change in position from day to day. Some females at 0° C., however, did not move and appeared dead but soon revived when brought into a warm room. Above 30° C. they were most active and the females did not oviposit.

METHODS OF FEEDING

The adult male and female will feed on honey or sugar solution but the preferred food of the female is the body fluids of the host.

The male does not feed from this source.

When about to feed on the host the female examines the cocoon very carefully with her antennæ. She then thrusts her ovipositor inside of it and very cautiously stings the host causing it to twist and turn spasmodically for several minutes. After that she merely holds her organ inside waiting for the host to roll against it. Sometimes she is able to keep her ovipositor in the host for several seconds and in that case it will writhe violently for a long time, and during this period she rests on the cocoon with her ovipositor withdrawn. She stings the host from 3 to 100 times before it is completely paralyzed, taking from 10 minutes to 8 hours. On the whole it requires less time to paralyze the prepupa than the pupa and this fact may account somewhat for the female's preference of the former as host.

After the host has become quiet the female crawls around the cocoon feeling with her antennæ or thrusting in her ovipositor at different points in search of the spot upon which to erect the feeding tube. Occasionally she will move the host into a more desirable position with the tip of her ovipositor. When the desired spot is found, usually the dorsal part of the abdomen, the ovipositor is thrust through the cocoon and into the host at this point and the distal end moved around several times inside the host in a circular manner. The female does this intermittently for 2 or 3 minutes and then withdraws the ovipositor until only the tip is in the host. At this time a chalky white fluid flows down the ovipositor to the host and quickly hardens. This continues for about a half minute and then she slowly pushes the organ deeper until it is as far in the host as she can push it. After that she very cautiously and slowly withdraws the ovipositor completely, leaving a white tube attached to the host and projecting slightly above the network of the cocoon. The entire procedure lasts from 5 to 10 minutes. Immediately after the ovipositor is withdrawn the female moves backwards and finds the end of the tube by the aid of her antennæ. Occasionally, especially with old females, the tube does not form owing to an insufficient quantity of fluid, in which case the female becomes greatly excited after fruitless searching. She will then make another tube nearby. When the tube is finally formed and located she quickly becomes calm and feeds by sucking the blood of the host through the tube. After feeding from 5 to 20 minutes without moving she leaves the cocoon and rests for several minutes before commencing to lay her eggs.

It is not always necessary that the female erect the feeding tube from outside the cocoon, as the author has observed her in many cases deliberately enter, after the host is paralyzed, and erect one there. In this case the tube projects only just above the host's body. A new tube is made for each feeding.

The feeding tube is similar in color but twice as large in diameter as the strands of the cocoon. It is very delicate and lightly attached to the host, as a slight movement caused by turning the cocoon always results in severing it. It is therefore very essential that the host be entirely paralyzed or the feeding by the parasite will be interrupted.

These operations incident to feeding are all very similar to those so aptly described by Lichtenstein (6), Picard (9), Voukassovitch (12), Faure (2), Trouvelot (11), Genieys (4), and Parker and Thompson (8), with closely allied chalcidoids and other parasitic Hymenoptera.

EFFECT OF PARASITE ON HOST

In her effort to paralyze the host completely the female stings it so violently that it dies. After one or two days the dead host has disintegrated to such an extent that it is no longer suitable to the female for oviposition, although she occasionally feeds from it at this time if no other source is available.

TABLE II.

Length of Life of Adults of *Dibrachoides dynastes* Under Various Conditions.

Temperature and Humidity	Food	Number Used	Longevity of Female		Number Used	Longevity of Male	
			Maximum	Average		Maximum	Average
25°–30° C. 40%–60%	Sugar solution	10	40 days	10 days	10	20 days	5 days
	Water only	5	6 days	3 days	5	5 days	2 days
18°–24° C. 40%–60%	Sugar solution	10	152 days	62 days	10	45 days	14 days
	Water only	5	8 days	5 days	5	5 days	3 days
8°–13° C. 60%–80%	Sugar solution	6	8 months	4 months	4	7 months	3 months
	Water only	4	1 month	9 days	4	15 days	7 days
0° C. 60%–80%	Sugar solution	3	3 months	23 days	10	28 days	10 days
	Water only	3	26 days	15 days	10	18 days	7 days

PARTHENOGENESIS AND PROPORTION OF SEXES

Like most chalcidoids this parasite reproduces parthenogenetically when the progeny are all males.

Judging from the material reared in the laboratory it would appear that the females are slightly more abundant than the males. Of 218 specimens, 119 were females and 99 males.

LONGEVITY

In order to secure data on the duration of the adult stage a number of each sex were placed at different temperatures and fed either with sugar solution or water. The results are summarized in Table II.

After the host has become quiet the female crawls around the cocoon feeling with her antennæ or thrusting in her ovipositor at different points in search of the spot upon which to erect the feeding tube. Occasionally she will move the host into a more desirable position with the tip of her ovipositor. When the desired spot is found, usually the dorsal part of the abdomen, the ovipositor is thrust through the cocoon and into the host at this point and the distal end moved around several times inside the host in a circular manner. The female does this intermittently for 2 or 3 minutes and then withdraws the ovipositor until only the tip is in the host. At this time a chalky white fluid flows down the ovipositor to the host and quickly hardens. This continues for about a half minute and then she slowly pushes the organ deeper until it is as far in the host as she can push it. After that she very cautiously and slowly withdraws the ovipositor completely, leaving a white tube attached to the host and projecting slightly above the network of the cocoon. The entire procedure lasts from 5 to 10 minutes. Immediately after the ovipositor is withdrawn the female moves backwards and finds the end of the tube by the aid of her antennæ. Occasionally, especially with old females, the tube does not form owing to an insufficient quantity of fluid, in which case the female becomes greatly excited after fruitless searching. She will then make another tube nearby. When the tube is finally formed and located she quickly becomes calm and feeds by sucking the blood of the host through the tube. After feeding from 5 to 20 minutes without moving she leaves the cocoon and rests for several minutes before commencing to lay her eggs.

It is not always necessary that the female erect the feeding tube from outside the cocoon, as the author has observed her in many cases deliberately enter, after the host is paralyzed, and erect one there. In this case the tube projects only just above the host's body. A new tube is made for each feeding.

The feeding tube is similar in color but twice as large in diameter as the strands of the cocoon. It is very delicate and lightly attached to the host, as a slight movement caused by turning the cocoon always results in severing it. It is therefore very essential that the host be entirely paralyzed or the feeding by the parasite will be interrupted.

These operations incident to feeding are all very similar to those so aptly described by Lichtenstein (6), Picard (9), Voukassovitch (12), Faure (2), Trouvelot (11), Genieys (4), and Parker and Thompson (8), with closely allied chalcidoids and other parasitic Hymenoptera.

EFFECT OF PARASITE ON HOST

In her effort to paralyze the host completely the female stings it so violently that it dies. After one or two days the dead host has disintegrated to such an extent that it is no longer suitable to the female for oviposition, although she occasionally feeds from it at this time if no other source is available.

TABLE II.

Length of Life of Adults of *Dibrachoides dynastes* Under Various Conditions.

Temperature and Humidity	Food	Number Used	Longevity of Female		Number Used	Longevity of Male	
			Maximum	Average		Maximum	Average
25°-30° C. 40%-60%	Sugar solution Water only	10 5	40 days 6 days	10 days 3 days	10 5	20 days 5 days	5 days 2 days
18°-24° C. 40%-60%	Sugar solution Water only	10 5	152 days 8 days	62 days 5 days	10 5	45 days 5 days	14 days 3 days
8°-13° C. 60%-80%	Sugar solution Water only	6 4	8 months 1 month	4 months 9 days	4 4	7 months 15 days	3 months 7 days
0° C. 60%-80%	Sugar solution Water only	3 3	3 months 26 days	23 days 15 days	10 10	28 days 18 days	10 days 7 days

PARTHENOGENESIS AND PROPORTION OF SEXES

Like most chalcidoids this parasite reproduces parthenogenetically when the progeny are all males.

Judging from the material reared in the laboratory it would appear that the females are slightly more abundant than the males. Of 218 specimens, 119 were females and 99 males.

LONGEVITY

In order to secure data on the duration of the adult stage a number of each sex were placed at different temperatures and fed either with sugar solution or water. The results are summarized in Table II.

As most of the adults were inactive at 0° C. they were brought into the room for an hour or so every few days to enable them to feed. Those placed at from 8° to 13° C. were able to feed at that temperature but were brought into the warmer room for a half hour or so about once a week to be certain that they fed. One female kept at from 5° to 13° C. lived from the middle of July to the following February, whereupon she was changed to 22° C. to induce oviposition. She laid 53 eggs and died March 15. If she had not been exposed to the higher temperatures she undoubtedly would have lived considerably longer.

EFFECT OF CONTINUOUS LOW TEMPERATURE ON THE ADULT MALE

When males were kept several weeks at constant temperatures below 8° C. and allowed to mate at the end of that period the resulting progeny of the mated females were all males.

SEASONAL HISTORY

This parasite normally has two generations annually in the Hyères district. The overwintering females parasitize the first weevil cocoons formed in the spring, which appear about the middle of April at Hyères. From the first to the second week of May the females of the first generation of the parasite emerge and attack the host cocoons. At this time, however, the weevils are practically all in the cocoon stage and rapidly changing to adults, so the parasite can not lay her normal number of eggs owing to the lack of hosts. The second generation of the parasite, therefore, is less numerous than the first. As there are usually a few scattered weevils in the cocoon stage to be found from the middle of May to the following fall, there is also a possibility of the occurrence of one or more additional generations, depending on whether the parasite can find any of the few scattered hosts present during that period.

HIBERNATION

All experiments made in the laboratory under conditions more or less comparable with those in the field tend to show that the parasite passes the winter as an adult.

HYPERPARASITISM

No hyperparasites of this species were reared by the author but Chamberlin (1) records a eulophid, *Pleurotropis* sp., as parasitizing the pupæ of *D. dynastes* to a small extent.

HOSTS OTHER THAN PHYTONOMUS POSTICUS

Adults of *D. dynastes* have been reared from field-collected cocoons of *Hypera nigrirostris* (Fab.) by L. P. Rockwood. The author has bred this parasite in the laboratory from cocoons of *Hypera punctata* (Fab.) and has reared as many as 13 full-sized adults from one host.

LITERATURE CITED.

(1) **Chamberlin, T. R.** 1924. Studies of the parasites of the alfalfa weevil in Europe. Jour. Econ. Ent. 17: 623–632.

(2) **Faure, Jean C.** 1924. Etudes sur la ponte et le mode de nutrition chez Pteromalus variabilis Ratz. et Eurytoma appendigaster Dalm. Chalcidiens parasites de l'Apanteles glomeratus L. Rev. Zool. Agr. et Appl., Ann. 23, p. [225]-233, illus.

(3) **Foerster, Arnold.** 1841. Beitrage zur Monographie der Pteromalinen, 46 p. illus.

(4) **Genieys, P.** 1925. Habrobracon brevicornis Wesm. Ann. Ent. Soc. Amer. 18 (2): 143–202, illus.

(5) **Kurdjumov, N.** 1913. Notes on Pteromalidae (Hymenoptera, Chalcidoidea). Rev. Russe d'Ent. 13: 1–24.

(6) **Lichtenstein, J.** 1921. Sur la biologie d'un chalcidien. C. R. Acad. Sci. 173 (17): 733–735, illus.

(7) **Parker, H. L.** 1924. Recherches sur les formes post-embryonnaires des chalcidiens. Ann. Soc. Ent. France, 93: 261–379, illus.

(8) ———, and **Thompson, W. R.** 1928. Contribution a la biologie des chalcidiens entomophages. Ann. Soc. Ent. France, 97: 425–465.

(9) **Picard, F.** 1922. Contribution a l'etude des parasites de Pieris brassicae L. Bul. Biol. Fr. et Belg. 56 (1): [54]-130.

(10) **Rockwood, L. P.** 1920. Hypera nigrirostris Fab. in the Pacific Northwest. Canad. Ent. 52: 38–39.

(11) **Trouvelot, B.** 1921. Observations biologiques sur l'Habrobracon johansenni Vier. C. R. Soc. Biol. 85: 1022–1024.

(12) **Voukassovitch, P.** 1924. Contribution à l'étude de l'eudemis (Polychrosis botrana Schiff.) de la pyrale de la vigne (Oenophthira pilleriana Schiff.) et de leurs parasites. Thèse à l'Universite de Toulouse. 248 p. Toulouse.

(13) **Webster, F. M.** 1912. A preliminary report on the alfalfa weevil. (Introduced parasites, p. 34–39.) U. S. Dept. Agr. Bur. Ent. Bul. 112, 47 p., illus.

PUBLISHED FIGURES OF DIBRACHOIDES DYNASTES IN LITERATURE.

(13) **Webster, F. M.** Fig. 19, adult female of D. dynastes; fig. 20, adult male of D. dynastes; fig. 21, pupa of alfalfa weevil with eggs of parasite in place; fig. 23, parasite larva feeding on alfalfa weevil pupa; fig. 24, male pupa of the parasite.

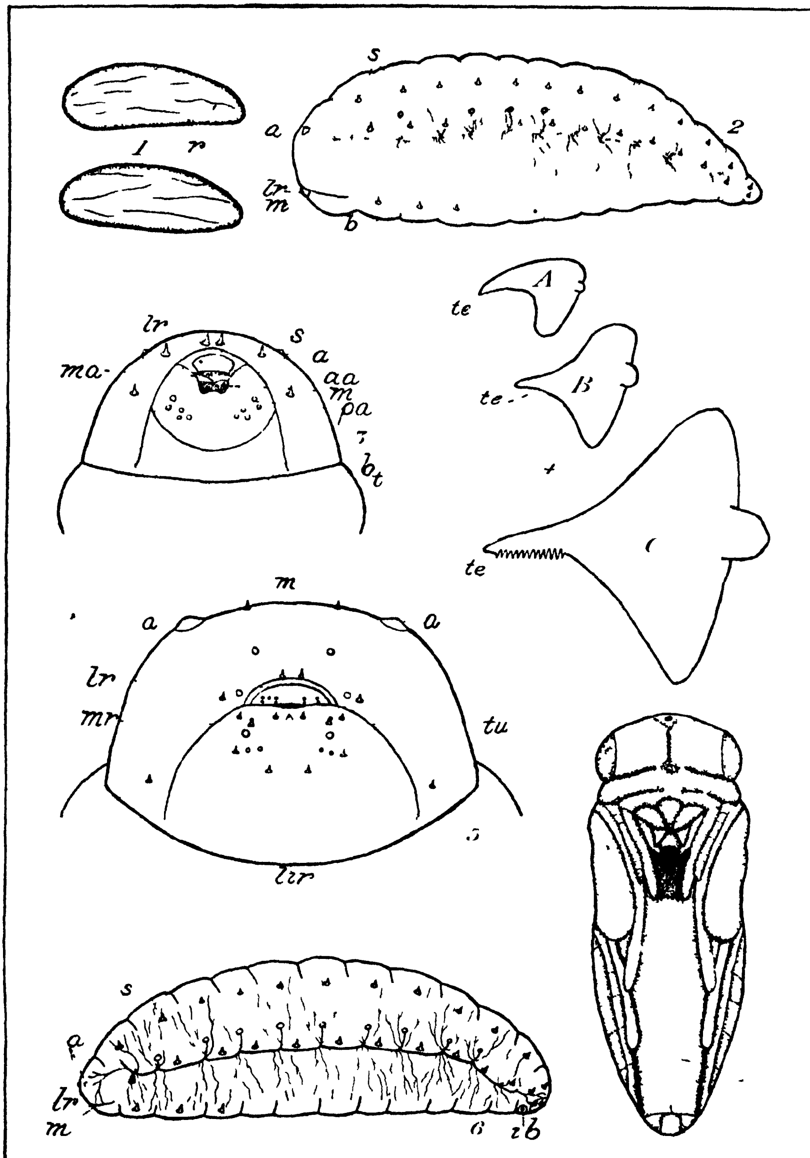
EXPLANATION OF PLATE

(All drawings much enlarged.)

Fig. 1. Eggs.
Fig. 2. First instar larva, lateral aspect.
Fig. 3. Head of first instar larva, ventral aspect.
Fig. 4. Mandibles of first (A), second (B) and fifth (C) instars.
Fig. 5. Head of mature larva, ventral aspect.
Fig. 6. Mature larva, lateral aspect.
Fig. 7. Pupa of female, ventral aspect.

LIST OF ABBREVIATIONS

a.......antenna.
aa......superior mandibular apophysis.
b.......band of minute spines.
ib......imaginal bud of male reproductive organs.
lir......labial region.
m......mouth opening.
ma.....mandibles.
mr......maxillary region.
pa......inferior mandibular apophysis.
r.......minute ridges.
s.......sensorial spines.
t.......tentorium.
te .....minute teeth.
tu......tubercle-like projection with circular area at tip.


s
a
lr
m
b
1
r
2
A
B
C
te
te
te
lr
s
a
aa
m
pa
ma
bt
7
m
a
a
lr
mr
tu
lir
5
s
a
lr
m
6
ib

NOTES ON THE LIFE-HISTORY OF LINDORUS LOPHANTHÆ.*

STANLEY E. FLANDERS.

Lindorus lophanthæ (Blaisd.) is a common coccinellid predator of red scale. If fruit heavily infested with red scale is placed in a container the larvæ of *Lindorus* appear in numbers as soon as the minute larvæ, which are usually present, increase

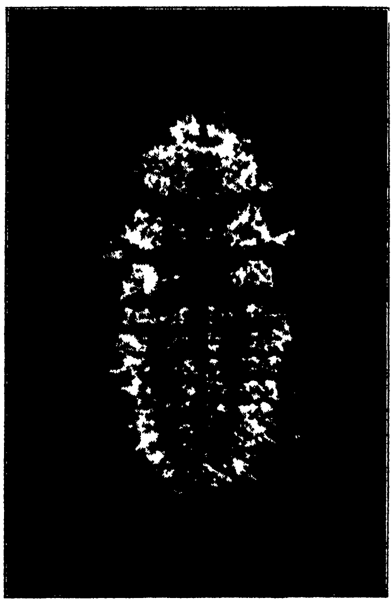


FIG. 1. Last stage larva of *L. lophanthæ* feeding.

in size. That larger larvæ are not found to be so plentiful on the fruit when on the trees is probably due to the fact that the young larvæ are active and have a tendency to drop off or crawl on to the limbs.

When black scale eggs were glued to the fruit the larvæ in the third and fourth instars seemed to prefer them to red scale. In order to obtain oviposition records it was necessary

*Paper No. 215, University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

to use black scale as a stimulus for egg deposition. In the field oviposition probably occurs on the limbs bearing red scale infested fruit. The writer has not as yet observed any eggs on the fruit. The instinct of the female to insert its eggs in crevices is illustrated by the fact that it occasionally will fill the space between the abdomen and elytra of dead adults with a mass of eggs.

The adult *Lindorus* is convex-oval in shape and varies from 2 to 3 mm. in length. The males may be distinguished from the females by the bifid claws of the first and second pair of legs and the emarginate posterior edge of the last abdominal segment. Mating occurs readily in confinement.

FIG 2. Eggs of *L. lophanthæ* deposited among black scale eggs glued to cardboard.

When paired and placed in a vial with an abundance of black scale eggs one female deposited among the black scale eggs as many as 144 pearly white or yellowish eggs. These eggs are elongate-oval and are approximately ½ mm. long.

Egg deposition begins on the third day after emergence. Just prior to depositing an egg the female is especially active, pivoting, and moving jerkily and sometimes exhibiting a pugnacious manner toward individuals near her. Oviposition may extend over a period of 20 days. The maximum daily egg deposition for one female was 25.

Although *Lindorus* exhibited a fondness for black scale eggs it can be reared successfully on them only after the second ecdysis. Newly-hatched larvæ placed on black scale eggs suffered a heavy mortality and the length of the first instar was three times that of those feeding on red scale. Moreover, all

of the second stage larvæ died with an abundance of black scale present.

On the third day of incubation of the egg the enteron of the embryo becomes yellowish in color and on the fourth and fifth days the dark gray larva is visible within the egg. Upon hatching the entire larva is silvery gray and the ocelli are red. Shortly afterward the head capsule turns black. The body is .6 mm. long upon hatching and just prior to first ecdysis is 1 mm. long. Two distinct dark dots on the first thoracic segment and four caudal hairs characterize this stage. In its following stages the larva is fringed with hairs. The body color after each ecdysis changes from a dark gray to light yellow. The young larva usually seeks a crevice such as under a loose fruit button in which to undergo ecdysis. The newly emerged last stage larva is approximately 3 mm. in length. A characteristic mark on the larva is a yellow dorsal streak due to the color of the middle third of each of the first four abdominal segments.

The life cycle is as follows:

Egg stage	5–6 days
First larval instar	3–3 days
Second larval instar	2–3 days
Third larval instar	3–4 days
Fourth larval instar	6–8 days
Pupal stage	4–5 days

Many larvæ can be reared in a small container such as a Petri dish 4 inches in diameter without a high degree of cannibalism. The writer placed 120 larvæ of all stages in such a container and reared all but 5 per cent. The pupal stage is most subject to injury by the larvæ.

RESPONSE OF THE ARGENTINE ANT (IRIDOMYRMEX HUMILIS MAYR) TO EXTERNAL CONDITIONS.*

LUCILE HERTZER,
Stanford University.

The following observations were made in an artificial formicary in the interest of recording the responses of the Argentine ant to varied conditions of humidity, temperature, and light, with particular reference to the care of their young.

I. HUMIDITY CHOSEN FOR YOUNG

In several of the larger formicaries under observation there were decided changes in the position of the young according as moisture varied. In order to find out if Argentine ant workers showed any preferences as to degree of humidity for different immature stages, a large formicary was made the subject of experiment. In this formicary all three young stages were present. There were three separate little shelters which they constructed out of particles of soil. Soil could be dampened directly in some places and be kept dry in others. By controling the dampness, the workers could be made to move their young to any elected spot as long as it was in the dark.

1. Shelter "2" was dampened most, shelter "1" less, and shelter "3" not at all. The next day the driest shelter was vacant, a large pile of larvæ and another of eggs were in the dampest, and pupæ were in the one only partly damp.

2. Later the sponge was dampened and the next day it was found that both the eggs and larvæ were near the sponge, while the pupæ were in shelter "1" which was dry, but not the driest.

3. The shelters were dampened as in 1 above. A day and a half later the positions occupied were as follows: driest place—deserted; less dry—pupæ, a few eggs, and a few larvæ ready to pupate; dampest—many eggs and larvæ.

*Contribution from the Entomological Laboratory of Stanford University, California.

4. Shelter "3" which had been deserted right along was dampened as well as shelter "2", while shelter "1" was left to dry.

Results as follows: shelter "1" (driest)—deserted, no young or workers; shelter "2" (dampest)—a large pile of eggs, a large pile of larvæ, the latter being in the damper place; shelter "3" (less damp)—two large piles of pupæ and some older larvæ.

5. One end of shelter "1" was dampened as well as No. "3".

Results: shelter "1"—pupæ were in the dry part, young larvæ in the damp part; shelter "2" (damp)—larvæ; shelter "3" (damp)—vacant.

6. Shelter "2" was made very damp.

Results: shelter "1"—larvæ in the damp part, pupæ in the dry part; shelter "2" (very damp)—no young; shelter "3" (very dry)—no young.

7. Shelter "1"—pupæ in the driest part, larvæ in the dampest part; shelter "2"—young larvæ in the damper part, eggs in the less damp part; shelter "3"(driest)—deserted.

8. Shelter "1" (dry)—pupæ; shelter "2" (damper)—larvæ; shelter "3" (driest)—no young.

9. Shelter "1"—larvæ and eggs on damp side, pupæ on dry side; shelter "2" (slightly damp)—pupæ; shelter "3" (driest)—nothing.

In seven similar cases pupæ were kept invariably in the drier, and eggs and larvæ in the damper part of the formicary. Few ants had been permanently in shelter "3". An attempt was made to force them there by allowing "1" and "2" to dry.

Results: shelter "3" (dampest)—eggs, larvæ, most of the workers, all six queens; shelter "2" (dry)—deserted; shelter "1" (dry)—pupæ.

As no definite discrimination had been observed between humidity chosen for eggs and larvæ, it was determined to dampen a space so small that all eggs and larvæ could not be placed there at one time.

Results in three cases were:

1. Larvæ in the dampest part; eggs in a less damp part close to the larvæ; pupæ in the driest.

2. Larvæ in the dampest part; eggs an inch away in a less damp place; and pupæ in the dry part.

3. Pupæ in dry part; eggs, a few larvæ, and pupæ where it was slightly damp; many larvæ in the dampest part.

Therefore, larvæ of the Argentine ant are kept by choice in a relatively humid place, eggs in a slightly less humid position, and pupæ in almost dry soil.

Very damp soil is also avoided. On two occasions, large colonies moved with all their young out of a wet formicary across a foot of water to another formicary where conditions were identical except for less moisture.

II. Temperature Preferred for Young in a Colony

A jar of ice was placed at one end of a galvanized pan three feet long and eight inches wide; an electric bulb, at the other end. Soil was put in the bottom of the entire pan covering up the bulb. The temperature ranged from 56° at one end to 122° at the other. Workers and pupæ were placed at the warm end. One hour and a half later they had settled down in one spot with their young in a pile. The temperature at this place was 70°. During the night it became much higher at this place and the young were moved to the opposite side where the temperature was 83°, some degrees lower than at the place they had deserted.

With another group of workers and young, the temperature chosen for the young was 77°. Using the same equipment, half the soil was dampened, and the other half left dry. Here two choices were to be made. The ants could choose almost any temperature and at the same time either dry or damp soil. Workers and larvæ were introduced upon dry and warm soil over the bulb. One hour later they had settled with their young on the damp side at 80°. Several days later all the soil was dry except under the ice jar. The ice had entirely melted. The temperature had risen considerably on the dry end. The young were found under the ice jar at a temperature of 66°. Here they chose a lower temperature because it was damp. This shows the importance of sufficient humidity.

In a glass tube a half inch in diameter and three feet long, a half dozen workers and young were introduced. One end of the tube was chilled to 37° and the other was heated to 134°.

There were all degrees of temperature between. The ants with their young settled where the temperature was 80°.

The workers chose for their young temperatures varying from 70° to 83° with 80° chosen most often, where temperature was the only factor. Where humidity entered in as a factor, they would choose a lower temperature in order to secure greater humidity, if moisture was not available at higher temperatures.

III. Reaction to Light

A Petri cell in which workers and young were established for several days was so arranged that one-half was in the light and the other half in semi-dark. The cell was turned so that the young were in the light. Workers immediately began carrying the one hundred eighty-six pupæ into the dark. This was accomplished in nineteen minutes. One worker transported a callow after all pupæ had been moved. The light was then reversed. All pupæ were again carried to the dark. A similar result was obtained each of ten times. The activity of changing the position of the young was often initiated by one ant. Others soon followed the example of the first.

In but a few instances have young been brought out into light and then only in dull light. When the soil became too dry in Formicary "25", workers twice carried part of their eggs and larvæ out into dull light by a damp sponge. In Formicary "6" workers did the same on one occasion. In another instance, pupæ were brought into the light when the soil was too damp. Young have never been observed in direct light in the field in natural conditions, but workers have been seen carrying pupæ up between two rocks where blades of grass allowed a dull light to penetrate.

In general workers with young show a definite negative reaction to light.

STUDIES ON THE ARGENTINE ANT QUEEN (IRIDOMYRMEX HUMILIS MAYR).*

LUCILE HERTZER,
Stanford University.

I. BEHAVIOR OF THE ARGENTINE QUEEN IN BROOD-REARING.

In the case of many species of ants the queens of the colony rear to maturity a first brood of minim workers which assume all nest duties. The queen henceforth gives herself up exclusively to laying eggs. She feeds from the tongues of her offspring and becomes indifferent to her young. She is practically a parasite, "a mere egg-laying machine."

The following observation serves to show that the Argentine queen actually takes part in brood rearing and is not merely an egg-laying machine. In a certain artificial formicary, February 26, 1929, a queen assisted four workers in taking an active part in the care of eggs, larvæ, and pupæ.

Observation 1.

A pupa was emerging from the larval skin. The moulted larval skin was hanging to the tip of the abdomen. The pupa's abdomen was undergoing strenuous contraction, the purpose of which was to rid itself of the shed skin. One or two workers had been licking the pupa almost constantly. At this time a worker carried the pupa toward the pile of young beside the queen. The queen took the pupa into her mandibles from the worker, placed it on the pile, and licked it with her tongue. After several minutes the queen removed the larval skin from the abdomen of the pupa with her mandibles. Taking this skin, she held it to the mandibles of the oldest larva that had not yet discharged the meconium. Soon she repeated this act. The observer was unable to determine whether the larva ate. Then the queen held her mouth to the larval mouthparts in the same manner that a worker regurgitates to a

*Contribution from the Entomological Laboratory of Stanford University, California.

larva. Several minutes later a worker held the larval skin to the mouth of the larva, and then another worker did the same. It fell and another replaced it. The queen again licked the pupa. She held her mouth to the mouthparts of two larvæ after which she put the larval skin partly in the mouth of the large larva. When she left, movement of the larval mouthparts was observed. Evidently the skin was being chewed. A worker walking past the larva knocked the skin out. It was replaced by another worker and the chewing movements were again in evidence. The queen spent several minutes in cleaning two larvæ and an older pupa. She then picked up the pupa, turned it on the other side, and cleaned that side. All this occurred in one hour. Several most important factors are shown:

(1) This queen was taking an active part in both feeding and grooming the young. (2) The queen was as active as any worker in the care of the young. (3) The queen cared for young in the presence of workers. (4) Larvæ will likely eat solid matter.

Observation 2—March 2.

Dampening of the soil caused four workers to start moving the young in the formicary. The queen assisted, carrying separately eggs, larvæ, and pupæ. Then for thirty minutes the queen spent most of her time licking the young, cleaning nearly all of them in this time, and rearranging the whole pile. Workers also attended them, but the queen was fully as diligent. Occasionally she stopped to clean herself. Twice she received regurgitated food. Three times she cleaned workers. After thirty minutes activity slackened, and she stood quietly by the young.

In five other formicaries queens attended by workers were observed on several occasions to aid workers in carrying young when the colonies were disturbed. In all these cases the colonies were small, fifteen workers being the greatest number present.

It is interesting in this very successful species of Formicidæ to find the queen not so specialized in habits but that she may share with the workers the care of the young.

II. Behavior of the Argentine Ant Queen with Reference to Colony Moving.

We know that ant colonies move about from place to place according to the conditions of their environment.

In order to determine the reactions of the queen with reference to the "moving phenomenon," a number of experimental colonies were set up and studied, with the following results. In each case, a colony had become established in a Petri cell on a platform over water. The colonies consisted of queens accepted by workers of an alien colony of the same species. Each colony had selected its abode from a choice of two or sometimes three Petri cells. A colony could be made to move by regulating humidity or light. Light, excessive moisture, and excessive aridity are equally avoided. The purpose of this experiment was to determine the queen's behavior—to see whether or not she selects the new living quarters, or follows the workers to the new place in the midst of moving activities, or moves because she is being left behind.

Case 1.

In the first instance the soil in the colony cell was allowed to dry. A second cell was more humid. Workers began to pass back and forth to this cell. In an hour the two colony queens went to the newly selected place, following the trail established by these workers. This trail covered a distance of twenty-six inches or what might have been directly accomplished in five inches. When the queens left, there were still ten workers in the cell. Twenty had already gone to the new place. Hence, the queens left in the midst of the moving activity, not waiting until they had been deserted. One hour passed before the old place was entirely deserted by the workers.

Case 2.

The colony cell was allowed to dry. One and a half hours after a second cell had been made of more suitable humidity, three workers were inspecting it. Soon there was a quick influx of workers into this cell, and in ten minutes the two colony queens came to the new place. When they left their nest, there were still eight workers in the cell. Twenty-two were in the new place or on the way there. Again, the queens had followed to the new abode amidst moving activity.

Case 3.

Workers started moving to the new place in numbers, carrying immature forms there. When more than half the young had been carried to the newly selected site, and more than half of the seventy-five to one hundred workers had moved, the colony queen came to the new abode. She had caught the moving spirit and had gone to the new place when only half of her workers had left her.

Case 4.

The colony cell was overdampened The workers started transferring to another cell within five minutes. After twenty workers were in the new cell, the colony queen went there, following the trail that the workers took. When the queen left, there were fully fifty in her cell with her In this case the queen early caught the moving spirit, leaving after two-sevenths of the workers had transferred to the new place.

Case 5.

The colony's cell was allowed to dry Within two hours after the soil in another cell had been dampened, it was being inspected by several workers. Twenty-five minutes later workers were moving young to the new place, following a definite trail. Ten minutes later the queen moved there when seventeen workers, or one-third of the colony was with her in her cell. Again, the queen left before she had been left behind.

Case 6.

In the sixth case of a colony moving from one Petri cell to another, the cause was disturbance by light Within fifteen minutes after an electric light was turned on in a room, all were quite excited in their cell, and some began moving to the other cell. Workers kept passing back and forth between cells. Fifty minutes after the light was turned on, the queen left for the newly selected cell. Thirty workers were still in the colony cell when she left, while thirty-five had already gone to the new location. The queen moved in the midst of the moving activity when slightly more than half had gone to the new place.

Case 7.

In the seventh case of a colony moving, the cause was excessive humidity. The soil was dampened gradually so as

not to disturb the ants by a sudden deluge. In twenty minutes a few began moving to another cell on the same stage and some young were taken there. Twelve minutes later they deserted this cell for a third. They kept moving back and forth from their cell to this third one, carrying young over, but often returning with them. Three-fourths hour later the queen went there. Eight-ninths of the workers had already left when the queen went to the new place.

Case 8.

The colony cell became dry. A second cell was dampened. Workers started moving their young to this place. The queen went to the humid cell when one-fourth the workers had transferred. Within two hours after the second cell had been dampened, all the young and most of the workers were in the new abode.

Case 9.

A colony cell was permitted to dry out. A second cell was kept humid. During the next twenty-five minutes after a few workers began looking around in the moist cell, many workers moved there, carrying young with them. The queen finally went unaccompanied over to the new cell, following the trail that all the workers had traveled. When the queen went to the new place, eight-ninths of the workers had already transferred to the new place.

Case 10.

The cause of moving was the admission of light when a light was turned on in the room. This time the queen went to the new place during the midst of the moving. When she left her place, there were twenty-five workers in the newly chosen cell, and forty still back in the old nest. She followed the same trail that the workers established. In this case five-thirteenths of the workers had moved when the queen did so.

The queen in no case selected the new abode. Workers always chose the new location and established a definite trail there before the queen transferred. On going to the new place, the queen always followed the workers' trail. The queens left for the new places when from one-fourth to eight-ninths of the workers had gone to the new abode. She did not in any case wait until she was deserted before she moved. She

seemed to catch the moving spirit from the workers, becoming active and restless before leaving her cell, but leaving voluntarily. She is not picked up and carried to a place of safety as are the eggs, larvæ, and pupæ.

III. Hostility Among Argentine Ant Queens and Among the Workers.

During the course of an extensive study of the Argentine ant in artificial formicaries, an opportunity was afforded to study the relations of queens of this species to each other.

According to the observation of Newell and Barber* "Queens never show the least hostility to each other." "It was our custom to put all surplus queens into one colony. As many as several dozen queens were sometimes in a colony at once, all living peaceably together, and with the number of queens sometimes exceeding the number of workers."

While it seems to be quite true, as evidenced by many experiments as recorded elsewhere, that in this species the individuals of a colony and even of alien colonies are amicably disposed toward one another, "viciousness" does occasionally break out, as the following observations testify.

On March 1, in a Petri cell in which for three days three queens of a certain colony called "k" had been confined without workers for a few days, one queen was found with only the left fore leg unmutilated. All other appendages were entirely or partly lacking. This queen was scarcely able to drag herself around. A second queen was also mutilated, retaining entire only three legs and one antenna. The third queen was unmutilated. Her thorax was slightly caved in, no doubt being injured during capture. This, however, did not seem to inconvenience her, though it may have had something to do with her subsequent behavior. At any rate it served as an excellent identification mark. Suspecting that this queen was the offender, she was carefully observed and in a half hour as she came in contact with the second queen, she bit her viciously. Fifteen minutes later, the performance was repeated. The attacker moved quickly and seemed greatly irritated, but she spent practically all her time in hiding. Observations at intervals up to ten o'clock that night revealed no more attacks.

*Newell, W. and Barber, T. C. *The Argentine Ant.* U. S. Dept. Agr. Bur. Ent. Bul. 122, pp. 50, 51, 1913.

By the next morning one mutilated queen was dead, and the other had portions of three more appendages bitten off. These appendages were removed between joints showing the effect of the queen's biting rather than of pulling, which is evident in attacks by workers. This second queen died during the afternoon.

Another "k" colony queen was then introduced. The two fed on honey side by side. After a while the fighter approached the other in a threatening manner with open mandibles, while the other cowered. Then the newly introduced queen was viciously grabbed by the hind leg, which was injured by the single attack. Each hid separately for two hours when they were prodded from their places. Running, they came in contact and several severe attacks followed, after which each lunged about frantically. Four workers of an alien colony of the same species were then introduced. The next morning one leg of the attacked queen was off beyond the femur, and one antenna lacked a few segments. During the next day all were apparently friendly, the queens tolerating each other. By the third day, however, the injured queen had suffered further mutilation. She died that afternoon. The fighting queen had killed three queens from the same colony as herself.

To see whether or not this queen would join an alien colony of the same species, the cell, in which she had been established for nine days with one egg, was placed over water upon a platform on which another cell was present containing an "E" colony queen and "S" and "O" colony workers, established together as one congenial group for three days. Two hours after the exits of the cells were opened, the isolated fighting queen was found by a colony worker. After a time more workers came, but not until almost two hours did this queen go to the colony cell. Her egg also was taken to the colony cell. Five minutes after she came to the colony, she was attacked by several workers. Some, however, engaged in cleaning her. Attacks were by no means continuous. Although this queen was not driven away, the next morning she was still occasionally attacked. Sometimes the two queens were together, but they were not evidently on good terms, because whenever they came bodily in contact with one another, the colony queen manifested definite and sudden withdrawal. After two days they were often together, but on the sixth day

the workers were attacking their own queen. Both antennæ and one leg were off. The queens for the next few days were often together. On the third day three more of the legs of the colony queen were off, and by the fourth day her body had been dismembered. The fighting queen was now on good terms with these workers and retained all her appendages throughout the next couple weeks. Whether or not the "K" colony queen took part in killing the colony queen is doubtful.

Another queen from "D" colony was introduced to this same group. Almost immediately she was attacked by workers. The fighting queen showed an irritability by several times opening her mandibles when the "D" queen approached, and finally she bit the "D" queen's petiole. The next day the "D" queen lacked both antennæ, but was thereafter tolerated but never closely associated with the "K" queen where the young were kept. Eight days after this "D" queen was introduced, the "K" queen was found to lack her two hind legs and an antenna. By this time the number of workers in the cell had greatly increased. Workers from a nearby colony had wedged into the cell. These were probably responsible for the mutilation of the "K" queen. Five days later this queen was beheaded. These workers had accepted permanently the "D" queen.

This observation showed that as social as the Argentine is, it would appear that nevertheless its queens are not entirely free from antagonism. This queen killed three queens from the same colony as herself, and attacked queens of other colonies. She attacked queens both when workers were and were not present.

IV. Hostility Among Workers.

Under two different circumstances hostility among workers has been observed.

1. *Pseudo-hostility.*

On November 20, 1928, outdoors, workers whose abdomens were distended with food were noticed returning to the nest. These were attacked by workers of the same colony coming from the nest with empty abdomens. The attacked workers showed no hostility in retaliation, but pulled hard to free their legs, mandibles, or antennæ from the grasp of their nest mates.

Sometimes they would free themselves and hurry on to the nest. Other times they would regurgitate to the worker, after which each cleaned itself and went on its way. One worker dragged its attacker a foot while the latter bit the other's leg. Then it stopped and regurgitated. Sometimes two would attack the same ant at once and both share in the regurgitated food. The purpose of this pseudo-hostility was solicitation of food.

2. Actual Hostility.

Two workers had been caring for young with a few other workers for more than two months. For a month these two had been faithfully tending the few larvæ alone. At the end of this time another worker was introduced. Soon one of the two attacked the newcomer on the leg and followed it around attacking its leg or antenna when opportunity offered. Each of them then several times bit the worker on the pedicel, causing it to dart away suddenly. After a half hour, the newcomer stayed away from the two workers who were keeping close to their larvæ. Whenever the intruder came in contact with them, she withdrew hastily and in three days she was killed. One of the faithful ones died also, having lost two legs in the fight. Another strange worker put in was not permitted near the young, and died within two days. A third died a day later with an injured abdomen. The faithful worker later also died.

A colony of queen and workers was established for two months with young. The number of workers was reduced to three. Workers from a table twenty-five feet away wedged an opening into the cell and thirty or more invaded it. There was great excitement in the cell. The opening was too small for the queen to leave. One worker was dead, being cut in two between the thorax and abdomen, a second was being severely attacked and died in an hour and a half, a third had two legs amputated and died later in the day. It appears highly probable that the workers attacked were those belonging to the queen. The queen herself was accepted. Her young were all eaten by the intruders.

BOOK NOTICES

THE BUREAU OF ENTOMOLOGY, ITS HISTORY, ACTIVITIES AND ORGANIZATION. By GUSTAVUS A. WEBER. Pages I–XII and 1–177. Service Monograph of the United States Government, No. 60. Published by The Brookings Institution, Washington, 1930.

This is a volume for students of administration and is a companion volume to No. 54, Bureau of Biological Survey and No. 59, Plant Quarantine and Control Administration, published by the same Institution. Part I, pp. 1–52, gives a brief history of entomological work by the Bureau and its fore-runners: Part II, pp. 53–99, outlines the varied activities of the Bureau, and Part III, pp. 100–114, outlines the organization of the staff and projects. These parts are broadly written and are not documented in a way that would open up sources of information to future students. Pages 115–172 comprise a series of appendices of a more specific nature including laws, nature of publications, financial statement and a ten-page bibliography on the administration and history of economic entomology. The last appears to be the most usable feature of the work. C. H. K.

THE GALL WASP GENUS CYNIPS, A STUDY OF THE ORIGIN OF SPECIES. By ALFRED C. KINSEY. Pages 1–577, 479 figures, including 69 maps. Indiana University Studies, Vol. XVI, 1929 (1930).

This remarkable work covers the taxonomy and distribution of twenty-six species that include ninety varieties of the holarctic Genus Cynips. The study covers a time of twelve years and field trips totaling thirty-two thousand miles. It is based on the study of fifty-four thousand galls and the microscopic examination of seventeen thousand insect specimens. Part I, pp. 7–78, is devoted to a theoretical discussion of the origin of species and is one of the best studies in print because based on such an enormous amount of data: Part II, pp. 79–430, is taxonomic, giving descriptions and distribution of each variety: Part III, pp. 431–577, is a series of appendices including bibliography, index, plates, excluded species, etc. This volume is systematic entomology as it should be done and is a book that should be studied for its methods by every student of systematic entomology. C. H. K.

ANNALS

OF

The Entomological Society of America

Volume XXIII DECEMBER, 1930 Number 4

NOTES ON OREGON ORTHOPTERA WITH DESCRIPTIONS OF NEW SPECIES AND RACES.*

B. B. FULTON,
North Carolina State College.

While associated with the Oregon Agricultural Experiment Station, from 1919 to 1924, the writer collected and studied the Orthoptera of the state as opportunity permitted while carrying on the regular economic work. The more important results of these studies are brought together in this paper, which is not intended as a complete list of the Orthoptera of Oregon. The part on distribution and ecological relations is placed last so that reference to new species and races will not precede their description.

PART I.

DESCRIPTION OF NEW SPECIES AND RACES AND SPECIAL NOTES ON OTHER SPECIES.

Blattidæ

Parcoblatta americana (Scudder)

Large and very small nymphs found in the fall; adults in May. This species, like most of the family, leaves its hiding places at night and prowls about in search of food. One adult was observed chewing at a hole in an apple about six feet above the ground.

*Published with the approval of the Director of Research as Paper No. 39 of the journal series.

Acrididæ.

Acrydium granulatum Kirby.

This is the most common grouse locust and seems to have practically state-wide distribution. It is found on damp ground whether in meadow or woods, mountain slope or marsh. Adults taken in June, July, August and October.

Telmatettix hesperus Morse.

This species has been found only on gravel and sand bars of rivers, where it is abundant. Adults were taken on the Willamette River at Corvallis in September, and at Eugene in November on the Umpqua at Roseburg in August, and by F. H. Lathrop on the Klamath River at Hornbrook, California in August.

Paratettix toltecus (Saussure)

This species was collected by F. H. Lathrop at the junction of the Klamath and Shasta Rivers near Hornbrook, Calif., a few miles south of the Oregon line. Hebard (8) records specimens collected at Corvallis, June 24, 1925, by E. R. Buckell.

Napaia aspasma (R. & H).

Found at the border line of forest and meadow at Woodruff Meadows, Jackson County, and one specimen among St. John's-wort on the south slope of Jackson's Hill, Corvallis, about a hundred feet from the forest border. This species stridulates by rubbing the hind femora against the tegmina. The song resembles that of *Chloeatis conspersa*, being a series of faint rasps about three or four per second. The species was described from Syskiyou, Oregon, where it was taken around the border line of mountain-meadow and forest, as were the writer's specimens.

Chorthippus curtipennis oregonensis (Scudder).

This race is very poorly defined. All of the Oregon material in the writer's collection has smaller and shorter antennæ in the male sex than eastern specimens, but this is a very uncertain character for the difference is not great. In western Oregon the tegmina of the males are much shorter than the abdomen and those of the females are about equal to the head and pronotum. This does not hold true for specimens from Woodruff Meadows or eastern Oregon, in which the male tegmina reach

or exceed the tip of the abdomen. A median carina on the fastigium of the vertex and black marks on the sides of the metazone of the pronotal disk, characters used by Scudder to define *oregonensis*, may be found in both races.

Arphia saussureana Bruner.

This species was identified by comparison with a specimen from Albany, Oregon, in the Hebard collection, which contains many specimens from California. It is a common species all over western Oregon and is readily distinguished from *Arphia pseudonietana*, which is common east of the Cascades, by the yellowish ventral portions of the body. In the latter species this part of the body is dark brown or black.

Camnula pellucida (Scudder).

A striking difference in general color exists between specimens from western and eastern Oregon. In the west it usually has a dull brown ground color on which the dark brown spots are not conspicuous, while in the arid regions the ground color is pale yellowish buff with contrasting brown spots or the spots may be much reduced.

This species is primarily a grass land species and does not occur to any extent under true desert conditions. It may be found abundant in mountains, valleys or in marshes, in eastern Oregon, and in hilltop or valley prairies in western Oregon. It has the unique habit of congregating for egg laying. At Fox, a bunch grass valley in the Blue Mountains, they selected small knolls or foothills near the forest, for their egg beds. The soil here was of hard texture or stony. Near Silver Lake and Klamath Falls the egg beds were in strips of tule or patches of grass above the general level of the meadow where the soil was full of matted roots.

Conozoa wallula (Scudder).

Although a number of species have been described in this genus the writer has not been able to discover any differences in Oregon specimens that are not covered by the range of variation. Specimens from near the type locality do not appear distinct from specimens from other parts of the state. The carina of the prozone may be notched or deeply cut and the ventro-posterior angle of the lateral lobes varies from a rounded to an acute angle, but is not produced into a tooth. Color

varies from brownish gray to clay color, many having the metazone of contrasting yellowish color. Hind tibiæ vary from yellow to bright red.

Trimerotropis fontana Thomas.

This species is quite variable in most of the characters used by McNeill (9) in separating the species of the *caeruleipes* group. The bands of the tegmina vary from much reduced or indistinct bands confined to the anterior portion or bands very much broken into small spots to very conspicuous bands contrasting strongly with the ground color. The last variation is more common in the Rogue River Valley. The markings of the under side of the hind femora vary in all localities where large series were collected. They may vary from one preapical dark spot on a pale ground, through intermediate stages to those having a pale apical spot on a dark ground. The infuscation of the apical portion of the wing and the distinctness of the band also show considerable variation in any one locality.

Trimerotropis koebelei (Bruner).

Three males and three females from Upper Klamath Marsh compared with the type of this species from Placer Co., Calif., in the U. S. National Museum, appear to be the same species. The specimens were taken in an open pine forest near the marsh. The species is characterized by the dark bands of the tegmina being limited to the lateral field and by a conspicuous whitish band across the face below the eyes extending to the middle of the upper part of the lateral lobes of the pronotum. Part of a series of what is evidently *T. fontana* from McKenzie Bridge show these same color characters less conspicuously. It seems entirely probable that *koebelei* will prove to be no more than one of the numerous color varieties of *fontana*.

FLIGHT STRIDULATION OF THE OEDIPODINÆ.

Arphia saussureana, *A. pseudonietana* and *Dissosteira carolina* produce a crackling flutter when they fly, the noise usually increasing as they suddenly descend from a horizontal flight. The sound may be compared to touching with a piece of paper a revolving wheel the spokes of which are evenly spaced. *Trimerotropis fontana*, *T. pallidipennis* and *Conozoa wallula* produce an undulating clatter in flight, a series of short

buzzing sounds not distinctly separated, at the rate of 3 to 5 per second for the first two and somewhat faster for *Conozoa*. The sound is like touching with a paper a revolving wheel which has a few spokes missing on one side. *Trimerotropis suffusus* produces a series of distinct snaps, about 4 per second. To carry out the analogy we may say that this sound is like touching a paper to the same wheel after removing all of the spokes but one. *Circotettix undulatus* and *C. shastanus* make much louder and sharper snaps which can best be compared to electrics parks, and vary this with an occasional snapping buzz. When not disturbed they may be seen hovering in the air while making the slower snapping noise about 12 to 20 times then suddenly dart with a spiral or looping movement while making the rapid snapping sound.

In a few experiments with some of the western Oregon Oedipodinæ the writer found that removal of the hind legs did not affect the sound. If the tegmina are removed a distinct fluttering sound is made but the louder clatter or snapping sound is absent. With only the tegmina present the grasshopper can fly a little but with no sound at all. When the posterior edge of the tegmina is trimmed off with a scissors the effect is the same as complete removal. Apparently the louder sounds are produced by striking the wings and tegmina against each other during flight.

All of these grasshoppers have a habit of jerking the hind femora upward while walking on the ground. This produces a faint rasping sound which cannot be heard unless the insect is quite close.

Hesperotettix brevipennis pratensis Scudder.

Specimens from La Grande are very similar to specimens of this species from Iowa but specimens from Ontario, Ore., are pale brown rather than greenish in color and have the median line of the pronotum pale with narrow black borders. The species of the genus are extremely variable and difficult to determine.

Melanoplus lovetti[3] new species. (Fig. 1—A, B, C, D, E.)

Type, male; Woodruff Meadows, Jackson County, Ore., Aug. 5, 1922. Types deposited in U. S. National Museum.

[3]Memorial to A. L. Lovett, who was with the writer when the species was collected.

Frontal costa between antennæ about as wide as interocular space, slightly wider below, narrowed above at junction with vertex to three quarters of width at antennæ; broadly and shallowly sulcate below ocellus, slightly convex above. Scutellum of vertex widest at anterior margin of eyes. Vertical width of eyes one and a quarter times horizontal width. Metazone of pronotum more tectiform than prozone, anterior pronotal margin truncate, posterior margin very broadly rounded, median carina distinct throughout, lateral margins of disk nearly parallel on prozone, diverging slightly posteriorly on metazone.

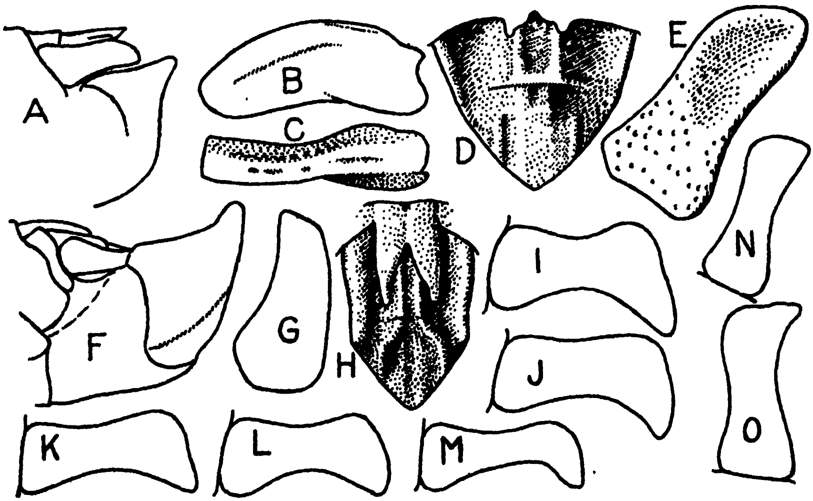


FIG. 1. A–E, *Melanoplus lovetti.* A, Lateral view of genital structures of type. B, Lateral view, middle femur, allotype. C, Dorsal view of same. D, Supra-anal plate, type. E, Cercus, type. F–H, *Melanoplus borealis palaceus,* type. F, Lateral view, genital structures. G, Cercus. H, Supra-anal plate. I–O, Cerci of saltator group of Melanoplus. I, *M. validus calapooyæ,* from Divide. J, K, *M. validus,* extremes of atypical series from Woodruff Meadows, L, *M. validus validus* from Medford. M, *M. validus pinicola* from Klamath Lake. N, *M. debilis?* from Holland. O, *M. validus,* atypical, from Upper Rogue River.

Prosternal spine cylindrical with short conical apex. Tegmina ovate, twice as long as broad, narrowly separated, apices angulate but rounded. Front and middle femora rather short and distinctly swollen, the ventral margins slightly concave in outline, the dorsal margins strongly arched. Middle femora with a rounded dorsal carina and dorso-lateral sulcus on the distal half. Interspace between mesosternal lobes quadrate; metasternal lobes sub-attingent. Dorsal surface of abdomen decidedly tectiform. Extremity of abdomen clavate and elevated. Supra-anal plate triangular; lateral margins broadly rounded in outline, depressed on proximal three fifths; median sulcus broad and deep on proximal third, interrupted at proximal two-fifths by a low narrow transverse carina beyond which narrowed median sulcus fades into an elevated broadly convex quadrate area bounded laterally by slightly higher,

short, parallel carinæ. Furcula, a pair of rounded lobes shorter than the segment bearing them. Cerci about as long as supra-anal plate but extending beyond; sides parallel at middle third, expanded at base to one and two-fifths times the middle width, lower margin nearly straight beyond middle, upper margin converging to a rounded tip, distal portion slightly hollowed externally. Subgenital plate with lateral margins straight in lateral view, sides below lateral margins and median portion distinctly concave so that the terminal portion is conical with a rounded apical tubercle.

Color: Top of head, pronotal disk, tegmina and dorsum of abdomen dull brownish (*Saccardo's umber to sepia* [3]). Underside *ivory yellow* to *cream buff*. Face *ivory yellow* on clypeus, *cream buff* to *chamois* above. Cheeks with a black patch extending below eyes, lower portion *cinnamon buff*. Sides of pronotum with a large black patch between the sulci with narrow extension above to anterior edge, remaining portion of anterior border and lower and posterior borders *cinnamon buff*. Sides of thorax and abdomen largely black except for narrow line of *cream buff* extending dorso-cephalad from hind coxæ. Sides of subgenital plate black. Supra-anal plate and distal portion of cerci *sepia*. Fore and middle legs *clay color* above, paler below. Outer side of hind femur *Naples yellow* at extreme base, shading to *clay color* distally, dorsal edge *clay color* with three patches of *snuff brown* which extend downward as obscure bands on the upper part of outer face; ventro-external face *rufous;* genicular lobes nearly black except distal halves of lower which are *cream buff*. Hind tibiæ pale dull yellow (*deep colonial buff*), spines black.

Allotype, female, same data as type.

Differs from the type in the following characters: Frontal costa between antennæ slightly narrower than interocular space and narrowing but little at junction with vertex. Pronotum relatively broader, with lateral margins of disk diverging more strongly and uniformly from anterior to posterior border, anterior and posterior margins of disk with very slight median emarginations. Tegmina relatively broader and more widely separated. Interspace between mesosternal lobes a little broader than long. Narrowest part of interspace between metasternal lobes about equal to length. Front femora not swollen. Middle femora more swollen than in the type, and decidedly arcuate, in dorsal view clavate and slightly sinuate the proximal three-fifths laterally compressed, the dorsal face flattened and sulcate distally.

Color: Generally lighter and more yellowish than type. Face, cheeks, most of lateral lobes and metazone of pronotum *Naples yellow*. Prozone and top of head *clay color*. Upper third of lateral lobes between the sulci *Saccardo's umber*. Legs *cinnamon buff*, hind femur with two obscure oblique bands of *clay color*. Abdomen and thorax *Saccardo's umber* dorsally, dark sepia on sides. Hind tibiæ pale brownish yellow with black spines.

[3]Names of colors in italics from Ridgway, Color Standards and Color Nomenclature, Washington, D. C.

Paratypes, 13 males, 4 females, same data as type.

MEASUREMENTS IN MILLIMETERS.

	BODY	PRONOTUM	TEGMINA	HIND FEMUR
Type	17	4.	4.5	9.
Allotype	23.	5	5.	11.
Paratypes:				
Males	16.-18.	4	4 -4.5	9.-10.
Females	21.-22.	4 5-5.	4.5-5.	10.-11.

One female paratype is lighter and more yellowish than the allotype, while two have about the same coloration as the type, including the rufous color on the ventral face of the hind femora. The males agree closely with the type except that three lack the rufous color on the ventral face of the hind femora and five have the borders of the lateral lobes of pronotum of the same color as the disk.

The species resembles *M. immunis* Scudder, from around Corvallis and *M. rehni* Hebard from Glendale and Siskiyou. The males can be distinguished from these species by the cerci which curve downward rather than upward. The females are readily distinguished by the peculiar middle femora. This species was found on the south edge of Woodruff Meadows in a small area which is so situated as to be shaded by the forest during most of the day. The ground was covered with moss and short grass. It was found less abundantly at the west edge of the meadow where the ground was damp and covered largely with herbs. None were found in the central portions or on the eastern and northern borders where the ground was dryer.

Melanoplus immunis Scudder (12).

This species is common on Mary's Peak (type locality) and Jackson's Hill near Corvallis, but to the writer's knowledge has not been found elsewhere. Probably it is confined to isolated hilltop prairies. In commenting on a series of specimens collected by the writer in the above localities, Morgan Hebard states in a letter that they prove beyond question that *M. usitatus* Scudder (12) is a synonym. The types of the latter were from Corvallis and probably came from one of the above places.

Melanoplus borealis palaceus,[4] new subspecies. (Fig. 1—F, G, H.)

Type, male. Upper Klamath Marsh, Oregon, Aug. 11, 1922. Types deposited in U. S. National Museum.

Frontal costa at junction with vertex as wide as interocular space; margins diverging slightly to ocellus, below that point subparallel, sulcate below ocellus. Horizontal width of eye four-fifths of vertical width. Pronotum truncate anteriorly, obtuse angulate posteriorly with broadly rounded apex. Median carina low on prozone, well marked on metazone. Prosternal spine in anterior view, slightly clavate, the apex a broadly rounded knob. Mesosternum slightly swollen, but uniformly so and in no sense tuberculate. Interspace between mesosternal lobes quadrate. Metasternal lobes attingent. Tegmina equal extremity of abdomen. Extremity of abdomen somewhat elevated. Subgenital plate long and with apex considerably elevated, in caudal view broadly truncated, caudal face flattened and slightly hollowed just below the apex. Furcula a pair of elongated flattened lobes reaching nearly to the middle of supra-anal plate, the external margins subparallel with each other, the inner margins attingent for two-fifths of length, beyond diverging to apices. Supra-anal plate with sub-parallel high rounded lateral margins on basal three-fifths and with a pair of rather sharp but lower median carinæ, the latter parallel as far as an obscure transverse carina near middle of plate, beyond that point diverging strongly as far as limits of raised lateral margins and beyond that point more elevated and diverging only slightly. Apical two-fifths of supra-anal plate triangular in outline and nearly plane except for the carinæ described above and an obscure median groove. Cerci narrowing to apex, upper margin concave, lower slightly convex, apex obliquely truncated forming an acute but rounded angle with the upper margin; basal width about twice the preapical width.

Color: Top of head and prozone *dark olive*, face and cheeks *citrine drab*. Lateral lobes and metazone *olive brown*. A black bar extends from eye to posterior sulcus of lateral lobe covering dorsal half of lobe. Tegmina *sepia*, with row of obscure darker spots in middle of lateral field. Antennæ, fore and middle legs and base of hind femora *clay color*. Dorsal face of hind femora *olive brown*, external face *olive brown* mixed with *clay color*, ventral face and hind tibiæ and tarsi *vinaceous rufous*. Sides of thorax and base of abdomen black. Ventral side of abdomen nearly to apex of subgenital plate *chamois*, the sides with ground color of the same, heavily mottled with black. Sides and apex of subgenital plate black.

Allotype, female; same data as type. Similar to type but considerably larger and stouter and with relatively more abbreviated tegmina, which fall short of tip of abdomen by 6. mm. Colors similar to those of type but of slightly darker shades. Antennæ have the same color as the hind tibiæ.

[4]**Pala, a shovel or spade, referring to shape of male subgenital plate.**

Paratypes, 4 males, 7 females; same data as type. All males have the tegmina about equalling the tip of the abdomen. In the females the tegmina fall short of tip of ovipositor, from 2 to 7 millimeters. Little variation in color. One male has sides of subgenital plate *sepia* instead of black.

MEASUREMENTS IN MILLIMETERS

	BODY	PRONOTUM	TEGMINA	HIND FEMUR
Type	21.	4.5	14.5	11.5
Allotype	30.	6.	15.5	15.
Paratypes:				
Males	19.-21.	4.3-4.7	12.5-15	11.5-12.5
Females	26.-30.	5.5-6 5	13.5-16.5	13.5-15.

These grasshoppers were found near the pine woods on the border of a large meadow land known as Upper Klamath Marsh, situated on the plateau between Crater Lake and Silver Lake. It differs from *M. borealis monticola* Scudder known from B. C. and Colo. in the elevated apex of the subgenital plate which shows no resemblance to the *femur-rubrum* group. In this respect it more nearly resembles *M. borealis* (Fieber), but judging by Scudder's figure (11) of that species it differs from it by having the subgenital plate more elevated than prolonged, the cerci less curved, and in lacking the sudden constriction of the elevated lateral margins of the supra-anal plate near its middle. In the shape of the subgenital plate it resembles *M. bruneri* Sc. and *M. excelsus* Sc. but differs from those species in the absence of a prominent tubercle on the mesosternum.

THE SALTATOR GROUP OF MELANOPLUS.

Melanoplus saltator was described by Scudder (11) from Portland and Oregon City. His figure does not show the usual form of the cerci and was either taken from an aberrant specimen or incorrectly drawn. Normally the apex is sub-truncate and with the caudo-ventral angle slightly produced into a rounded lobe. Later Scudder (12) described four more species in this group but did not so place them. They are as follows: *Ascensus* from Mt. Shasta, Calif., *validus* from Divide, Roseburg and Grants Pass with which were listed specimens from Portland, Corvallis, Philomath, Drain, Roseburg and Glendale; *algidus*

from Mary's Peak; and *debilis* from Ashland and Siskiyou. The Willamette Valley specimens which Scudder listed with *validus* must have belonged to *saltator* if they were correctly labelled, but it seems strange that he would not recognize them for the male supra-anal plate is distinctly different from that of any of the other members of the group. Hebard (7) described another member of the group, *calapooyæ* from specimens collected at Divide and Drain and states that Scudder's specimens of *validus* from the former locality would belong to this species, and restricts *validus* to the more southern localities.

The writer collected specimens of this group whenever opportunity permitted in an effort to delimit the range of the various species more accurately. Specimens from Portland, Forest Grove, Salem, Mary's Peak, Alsea Mountain, Corvallis and from various points on the Corvallis-Eugene road up to the north edge of Eugene, all proved to be *saltator* and exhibit very little regional variation. The series from Mary's Peak shows that Scudder's *algidus* is undoubtedly a synonym. Two miles southeast of Eugene *saltator* was absent but in exactly the same type of habitat the writer found typical *calapooyæ*. This was also found at Cresswell, Cottage Grove, Divide (Fig. 1, I) and Drain, showing that the range extends over the divide from the Umpqua Valley to the upper portions of the Willamette. South of Drain the writer's collections are more fragmentary but four males from Medford (Fig. 1, L) and one each from Ashland, Canyonville, and Roseburg are indistinguishable by any characters yet discovered and are assumed to be Scudder's species *validus*. Three males from Holland (Fig. 1, N) in the upper part of the Illinois Valley are doubtfully assigned to *M. debilis** since part of Scudder's series came from Siskiyou in the same range of mountains further east. One of the characters given by Scudder for this species is that most of both sexes have glaucous hind tibiæ. In the other species the hind tibiæ of the females are pink, red or reddish brown. Unfortunately no females were collected by the writer at this locality.

The three males mentioned above and the males of all specimens ascribed here to *validus* have the hind tibiæ ***bluish glaucous*** or ***dark bluish glaucous***. The males of *calapooyæ* have

*Since this manuscript was written one of the above specimens was sent to Hebard who identified it as the closely related *M. ascensus* described from Mt. Shasta.

the hind tibiæ a *cinnamon buff* with the proximal half more or less suffused with brown on the ventral side and *bluish glaucous* on the dorsal side between the rows of spines. In *saltator* the male hind tibiæ are generally dull *bluish glaucous* blended with *cinnamon buff* distally. A few have practically the same color of tibiæ as *calapooyæ*. The females from all localities have the hind tibiæ light or dark red but in the vicinity of Eugene a large number of both *saltator* and *calapooyæ* have this color strongly obscured with brown.

A series of 19 specimens from Woodruff Meadows (Fig. 1, J, K) and 4 from farther up the Rogue River toward Crater Lake (Fig. 1, O) had *coral red* hind tibiæ in both sexes. The male cerci of these series were compared to those from other localities by means of drawings made to the same scale by means of a cross lined eyepiece micrometer. As a group the cerci were intermediate in form between those of *validus* and *calapooyæ*. Some proved to be almost identical with those of specimens from Medford or Drain. The Woodruff series also occupied an intermediate position in regard to the structure of the male subgenital plate which has a somewhat higher median production of the free margin in *calapooyæ* than in *validus*. The writer was unable to separate the two on the characters of the supra-anal plate and is forced to the conclusion that *calapooyæ* is of subspecific rank. The differences other than those mentioned are the slightly larger size, more robust form and generally darker color of the latter. In general color the Woodruff series is like *calapooyæ* except in the color of the hind tibiæ which is like the new subspecies described below from regions farther east.

Melanoplus validus pinicola,[5] new subspecies. (Fig. 1, M)

This representative of the saltator group found in the pine forest east of the cascade divide seems worthy of subspecific rank. In linear arrangement *validus* would come between this form and *calapooyæ*.

Type, male, west side of Klamath Lake, Oregon, Aug. 7, 1922. Types deposited in the U. S. National Museum.

General structure similar to *M. validus validus*. Tegmina slightly longer than pronotum, attingent, twice as long as broad, apical portion rectangular but apex rounded. Supra-anal plate with rectangular

[5]Pinicola = pine dweller.

basal portion and triangular apical portion of about equal length; basal portion one and a half times as broad as median length, with a median groove bounded by low ridges, lateral margins elevated; triangular portion with lateral margins not elevated and slightly convex in outline, median portion with broad groove bounded by low ridges which diverge anteriorly and with increased elevation curve outward and meet the lateral margins at the base of the triangular portion. Cerci narrowest near the middle, length nearly five times middle width, base twice the middle width; concave on both margins, the apex curved strongly inward and prolonged caudo-ventrad. Subgenital plate slightly elevated at apex; very similar in structure to that of *M. validus validus*.

Color: Face and cheeks *olive-buff*. Ventral side of body, ground color of legs, and oblique bar on metapleura, *cinnamon-buff*. Dorsal portions of body a very dark brown. Lateral portions of meso- and metathorax and abdomen black. Shiny black postocular bar reaches to metazone. Fore and middle femora tinged with brown distally. Hind femora largely black on outer and dorsal faces, outer face with base and a V-shaped bar near middle *cinnamon-buff*, inner dorsal face with two bands of *cinnamon-buff*, ventral face deeply suffused with *coral red*. Hind tibiæ *coral red*.

Allotype, female; same data as type.

Shows no structural characters to distinguish it from the female of *M. validus validus*. Color similar to type except that face and cheeks are olive brown and ventral faces of hind femora are less strongly suffused with red.

Paratypes, 3 males, 2 females, same data as type; 2 males, 2 females, Upper Klamath Marsh, Aug. 11, 1922; 1 male, 1 female, Anna Creek, on road from Crater Lake to Fort Klamath, Aug. 7, 1922.

MEASUREMENTS IN MILLIMETERS.

	Body	Pronotum	Tegmina
Type	17.	4.	4.8
Allotype	22.	4.7	4 5
Paratypes:			
Males	17.–19.	4	3.2–4 8
Females	20.–22.5	4.5–5.4	3.8–5.5

Males of the paratypic series are all very similar to the type in color, but the females show some color phases of the same kind that occur in the females of other members of the saltator group. The two females from the type locality are similar to the allotype, the one from Anna Creek is entirely buff in color

with no dark marks, one from the upper marsh is buff with brown markings and the other is similar but with a decided reddish cast to the dorsal area. All of the paratypes have the *coral red* hind tibiæ but about half of them lack any reddish color on the ventral face of the hind femora.

Melanoplus mexicanus bilituratus (F. Walker).

After studying a large number of specimens from all parts of the state the writer has concluded that all of the *mexicanus* (*atlanis*) group of *Melanoplus* in the collection should be placed in this race. The proportions of the male cerci vary from a little less than twice as long as middle width to nearly three times as long as broad as measured under a microscope with an eyepiece micrometer. The prevailing color of the hind tibiæ over most of the state is red but specimens with glaucous tibiæ occur in series from Corvallis, Hood River, Baker, Drain and Malin. In the Malin series there are only a few with red tibiæ and this series also has consistently narrower male cerci. This series approaches closely to the *devastator* group, and may possibly represent another geographical race but certain specimens from other series approach them so closely that the degree of difference is very slight. This condition agrees with a note by Scudder (11) to the affect that examples from British Columbia and Washington come closer to *atlanis* than those from Nevada.

Melanoplus bruneri Scudder.

Six males from Drain and two males from Grants Pass agree with specimens of this species from South Dakota and Colorado The elevated tip of the subgenital plate is rounded, truncated or slightly notched. In one of the Drain specimens it is decidedly rounded and differs in no important respect from the specimens from the known range of *bruneri*. For this reason these specimens are placed there rather than under *alaskanus*. All were taken in rather hot and dry valley fields.

Melanoplus devastator Scudder.

This species which has practically state-wide distribution exhibits a considerable range of variation even in the same locality. In the majority of specimens the cerci are about three times as long as middle width by actual measurement. At Corvallis it was noted that in certain dry fields and on hilltops the specimens averaged smaller than usual and that the

cerci were relatively more slender attaining a length of four times the middle width. In the shape of the cerci and subgenital plate there is slight difference between extremes of this species and the series of *M. mexicanus bilituratus* from Malin. The shape of the furcula, supra-anal plate and swelling on the mesosternum help to distinguish the two species. Two specimens from Ontario, Calif. have the usual form of supra-anal plate and mesosternum but with cerci only slightly more slender than the Malin specimens mentioned above and with a furcula very much like that of *bilituratus*.

Oedaleonotus enigma (Scudder).

Three males and one female from Hermiston and two females from La Grande. All have the tegmina slightly longer than pronotum. In a series from Wieser, Idaho, four males and one female have tegmina as above, two males and two females have longer tegmina up to one and a half times the pronotum. Of three females from Ontario one has tegmina as long as pronotum, another has tegmina and wings about twice as long as pronotum, and the third has these organs exceeding the hind femora.

Oedaleonotus borckii borckii (Stal).

One male and three females from Grants Pass agree with this species in large size and relatively larger females and form of the mesosternal interspace, but contrary to Scudder's key, (11, 12) all have the dark color of the pronotal lateral lobes extending over the metazone, but in two females the dark band is reduced and confined to the upper margin on the metazone.

Oedaleonotus borckii pacificus (Scudder).

Twelve males and three females from Woodruff Meadows, agree with this race in the size and equality of sexes and in form of mesosternal interspace but in all the dark band of the lateral lobes is confined to the prozone. According to Scudder (11, 12) this color character applies to *borckii*.

Oedaleonotus borckii orientis Hebard (7).

Two males and four females from Merrill found in sage brush desert at edge of marsh bordering lower Klamath Lake. This record extends the known range of the species several hundred miles, the nearest previous record being northeastern Nevada.

Tettigoniidæ.

Phaneroptera furcata furcata, (Brunner).

The stridulation of this species may be of three kinds. The note most frequently heard is a single sharp "zip" made at infrequent intervals by simply separating tegmina and bringing them together again. Another note frequently heard is like the single note rapidly repeated three or four times as if the tegmina were vibrated, while bringing them together. The third form of stridulation has never been observed by the writer outside of Oregon. It consists of a ticking noise like that produced by picking the tip of one thumb nail with the other. The sound is usually repeated several times in series but the frequency varies from two or three seconds apart to a rate too rapid to count. In late afternoon in patches of oak scrub the males perch on the uppermost leaves and appear to be sending Morse code messages to each other. This is probably the most common sound made but is less often heard because it does not carry far. The sound is made by rotating the tegmina on their axes so as to raise the dorsal areas and suddenly bring them together again. Since the sound can be produced if the distal portions of the tegmina are removed it seems probable that it is caused by striking the stridulatory veins together. The female occasionally produces a somewhat fainter sound in the same manner.

The writer has watched the process of egg laying in the margins of leaves and his observations agree with those of Riley (10) except that the insect grasped both the edge of the leaf and the ovipositor with the mandibles instead of merely holding the ovipositor. In this manner the ovipositor was held against the thin chewed edge of the leaf while the sawing process of sliding one set of blades on the other split of the leaf.

In mating the male places the posterior end of the body in front of the female and elevates the wings without spreading them. The abdomen is bent downward and the female licks at the dorsal surface working toward the base of the wings. The male moves backward and extends the tip of the abdomen. The transfer of the spermatophore was not observed. At one time two males were observed with one female. The female moved away after licking the back of one male and the second male took her place and licked at the back of the first male for several minutes. The latter apparently became suddenly aware

of the substitution and kicked the other male with one hind leg and moved away giving vent to several "zips" that seemed to be an expression of irritation. The writer could find no trace of any glandular secretion or of any gland openings on the male but the mating process is very similar to that of the tree crickets in which an alluring gland is known to be present.

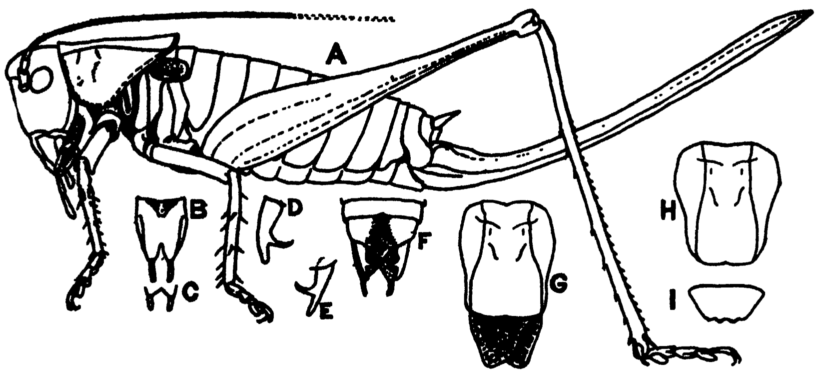


FIG. 2. *Steiroxys strepens*. A, Allotype. B, C, Subgenital plates of paratypes showing extreme conditions in form of terminal notch (B) from Corvallis, (C) from Woodruff Meadows. D, Cercus of Woodruff Meadows paratype. E, same, of type. F, Dorsal view, tip of abdomen, type. G, Pronotum and tegmina, type. H, Pronotum, allotype. I, Subgenital plate, allotype.

Steiroxys strepens[6] new species. (Fig. 2).

Type, male, from top of Jackson's Hill 6 miles North of Corvallis, Ore., July 9, 1922. Types deposited in U. S. National Museum.

Vertex well rounded in profile joining the occiput with scarcely any change in curvature. Eyes nearly circular in outline. Pronotum with well marked median and lateral carinæ. Lateral carinæ converge slightly to the first sixth, diverge to the posterior two-fifths, remaining portions parallel. Disk of pronotum nearly flat, truncate anteriorly, slightly rounded posteriorly; anterior margin three-fourths as broad as posterior margin. Lateral lobes one and three-fourths times as long as deep; posterior margin distinctly sinuate. Tegmina project a little less than half the length of pronotum; outer margins sharply inflected beneath a stout curved vein so as to be invisible from above. Front tibiæ armed above with three spines on outer border and below with six spines on both borders. Middle tibiæ with four rows of spines but only two in upper anterior row. Hind femora unarmed. Distal three-fourths of hind tibiæ with a few short spines on both margins below and with numerous close set short spines on both margins above;

[6] *strepens* = noisy.

with short and long subequal pairs of apical spurs below and a short pair above. Abdomen without a trace of raised median carina. Tenth abdominal segment notched posteriorly; dorsal median portion for full length of segment of sunken soft integument covered with fine hairs. Supra-anal plate appears as a triangular projection deeply hollowed above. Subgenital plate with sub-parallel lateral carinæ extending to bases of finger-shaped styles; a V-shaped notch between the styles. Cerci gently curved throughout on outer border; terminal portion finger-shaped, nearly straight and with rounded apex. A curved spine projects perpendicularly inward just beyond the middle of the cercus and terminates in a sharp claw.

Color: Grass green when alive. Dry specimen a light yellowish brown with greenish cast on legs.

Allotype, female, same data as type.

Disk of pronotum narrower than in the male and less expanded posteriorly. Tegmina small ovate pads projecting from under the posterior portion of the lateral lobes. Subgenital plate with posterior border about half the anterior border; sides nearly straight; posterior border with a shallow rounded median notch and a pair of smaller lateral excavations. Ovipositor slender, strongly curved at base but with distal half nearly straight

Paratypes, 5 males, 7 females, same data as type, and 11 males from Woodruff Meadows, Jackson County, Ore., about thirty miles southwest of Crater Lake, altitude 2800 feet. In the shape of the pronotum, tegmina and last dorsal segment of abdomen the series holds fairly constant. There is some variation in the proportions of the male cerci and subgenital plate in the series from both localities. The male cerci of the Woodruff Meadows series have on the average a stouter and shorter apical portion and a longer and more slender inner spine. The notch of the male subgenital plate varies from a slightly obtuse to a slightly acute angle in the southern specimens and from an acute angle to a deep acuminate V-shaped notch in the Corvallis series. The styles of the subgenital plate are also more slender in the latter series.

In color all agree with type except one of the Woodruff Meadows series which appears to have been light brown when alive. The hind femora of this specimen have numerous dark brown transverse streaks near the base; the lateral lobes of the pronotum are dark brown with buffy ventral and posterior borders; the vertex is outlined on sides and anteriorly with a blackish U-shaped mark.

The species differs from others of the genus in the shape of the male cerci. From specimens at hand of what appears to

be *S. pallidipalpus* they differ in the absence of any trace of abdominal median carina, broader pronotal disk, more slender ovipositor, larger size and in the shape of the hind tibiæ, which are narrower in longitudinal diameter. From the lateral view the hind tibiæ are not much broader than from the posterior view, while in *S. pallidipalpus* the lateral width is fully twice the posterior width.

MEASUREMENTS IN MILLIMETERS.

	PRONOTUM	HIND FEMUR	HIND TIBIA	OVIPOSITOR
Type	7.2 x 4.4	19.	18.5	
Allotype	7.4 x 3.9	23.	21.	27.
Paratypes: (extremes)				
Males—				
Corvallis	7. x 4.2	20.	19.	
	8. x 4.8	21.	20.	
	7.6 x 4.			
	7.8 x 5.			
Woodruff M	6 8 x 4.6	18.5	17.	
	7.8 x 5.	19.5	18.	
	7.4 x 4.4			
Females	6.8 x 4.2	21.	20.	24.
Corvallis	7.4 x 4.	22.5	21.5	26.
	7. x 3.7			

The presence of these insects was revealed by their song which is a series of very short rasping chirps. It starts with a few notes per second but quickly increases the speed to a rapid flutter which is kept up for a long period. On Jackson's Hill north of Corvallis it was common on the northwest side of the summit and in a small patch of prairie in a pass between that hill and the next one to the north. It was usually found where somewhat taller prairie plants and patches of brake fern occurred. At Woodruff Meadows it was common in clumps of grass or herbs over most of the meadow except the wet central portion.

On Jackson's Hill the species was found in the first and second instars on April 26, 1923, and in the last and next to last nymphal instars on May 25, 1924. In the first instar the ground color is very pale brownish gray, with the sides of thorax and abdomen entirely black except the posterior borders of the lateral lobes which are ivory. An ivory line borders the black

above on the abdomen and the median line is bounded by narrow black lines from vertex to tip of abdomen. In the second instar the black lines are partly faded and the black of the sides reduced to the extreme upper portion, while the remainder of the sides is pale green. In both first and second instars the vertex protrudes forward as a rounded knob.

Neduba carinata Walker.

An account of the habits, life history and remarkable range of color variation of this species has been published elsewhere. (6)

Cyphoderris piperi Caudell

This species was originally described as a subspecies of *monstrosa* by Caudell (1). When a series of males collected by the writer near Woodruff Meadows were compared with males of *C. monstrosa* collected in British Columbia by E. R. Buckell it was found that the genitalia were strikingly different. Drawings of the genital armatures were compared with the types of *monstrosa* and *piperi* by Nathan Banks and A. N. Caudell respectively and both agreed that they represented distinct species; the British Columbia specimens corresponding with the type of *monstrosa* and the writer's specimens with *piperi*. The writer first encountered this insect in the forest near Woodruff Meadows. While setting up camp by a small river at dusk my attention was attracted by a song that sounded like a small cricket in a clump of small bushes a few feet away. It was a high pitched metallic trill one to three seconds in duration and repeated at a rate of about fifteen times per minute. When the apparent source of the sound was reached the singer still seemed to be several feet away and it soon became evident that the song produced an auditory illusion of nearness that was very deceptive. After stalking the sound back into the woods about a hundred yards I discovered the insect sitting on a branch of a small fir a few feet above ground. At close range the sound was loud, penetrating and shrill and with a rapid pulsation or beat. Mr. A. N. Caudell told the writer that he experienced the same auditory illusion when he collected the type on Mt. Ranier. The first few specimens caught were grabbed at quickly so as to give no opportunity for escape but later the writer decided to test the insect's agility. When the antennæ were touched it moved backward along the branch and when the body was touched it simply dropped to the ground and remained motionless. When

touched again it turned over on its back as if dead. With further stimulation it would try to crawl away or remain motionless. They would stop singing at the slightest jar of the ground but were not disturbed by a flash light. Most of them were on low branches but one was found on the ground and another about ten feet above ground. The latter was not disturbed at first and several hours later was found in the same place and induced to drop to the ground by touching it with a stick. At Crater Lake they were usually beyond reach in the trees, the exact height difficult to estimate. In the evening one was observed there to have twenty notes per minute. They sing from dusk until the temperature drops too low for activity.

Tropidischia xanthostoma (Scudder).

Notes on this species have been published (5).

Ceuthophilus agassizii (Scudder).

On Oct. 8, 1923, several adult specimens were found in some old rat or gopher holes under a board near the college barns at Corvallis. They were kept in a cage for several weeks and fed on pieces of meat and apple. The mating process observed differs so much from other Tettigoniidæ that it seems worthy of mention. The male would walk backwards toward the female and on touching her would twist the abdomen so as to bring the ventral side of the tip in contact with the base of the ovipositor. They would remain for a minute or two with heads in opposite directions. Many attempts seem to be necessary before mating actually takes place. The process was observed several times and no spermatophore was formed. These specimens and one collected by L. P. Rockwood at Forest Grove were identified by T. H. Hubbell.

Gryllidæ.

Oecanthus.

This genus is represented in Oregon by three species, *californicus*, *nigricornis*, *argentinus* and *niveus*. The last is represented by two physiological races an account of which has been published (2). A general account of the species with detailed description of *califonicus* (3), and a special study of the *nigricornis* group (4), have also been published.

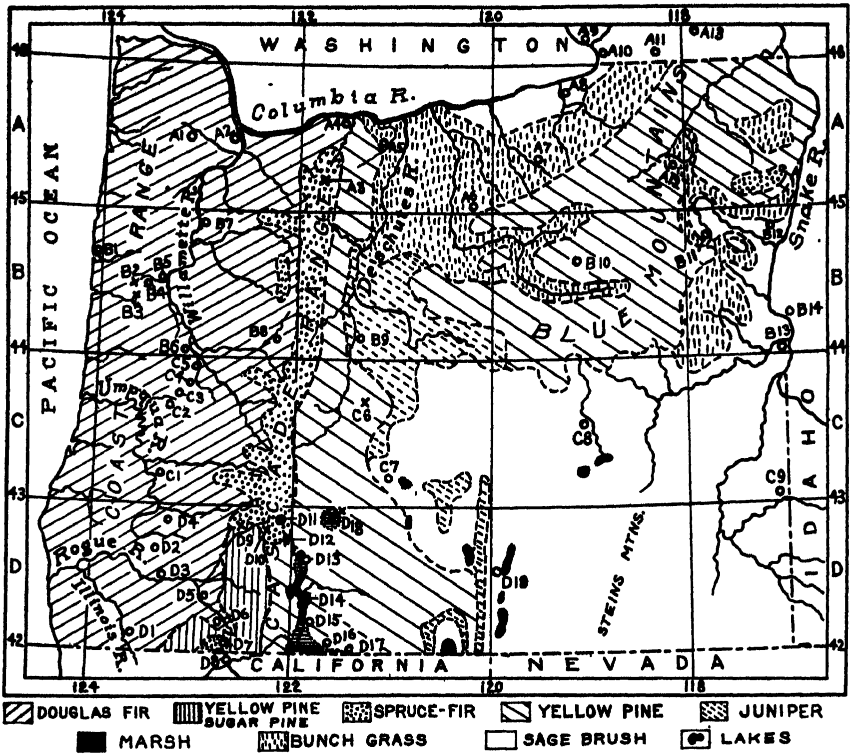


FIG. 3. Map showing natural vegetation areas of Oregon. (Copied from Shantz and Zon, 13.) Localities mentioned are listed alphabetically with numbers appearing on the map. Letters refer to horizontal grouping between the parallels of latitude; each group is numbered from west to east. Cities and villages are indicated by circles, other localities by crosses.

Alesa Mountain	B 3	Glendale	D 2	Newport	B 1
Anna Creek	D 12	Grants Pass	D 3	Ontario	B 13
Ashland	D 6	Halfway	B 12	Pasco, Wash	A 9
Baker	B 11	Heppner	A 7	Paulina Mtns	C 6
Bend	B 9	Hermiston	A 8	Philomath	B 4
Burns	C 8	Holland	D 1	Plush	D 19
Canyonville	D 4	Hood River	A 4	Portland	A 2
Cottage Grove	C 4	Hornbrook, Calif.	D 8	Ronan, Wash	A 13
Crater Lake	D 11	Jordan Valley	C 9	Roseburg	C 1
Creswell	C 5	Klamath Falls	D 15	Salem	B 7
Divide	C 3	Klamath Lake	D 14	Silver Lake	C 7
Drain	C 2	La Grande	A 12	Siskiyou	D 7
Dufer	A 5	McKenzie Bridge	B 8	Upper Klamath Marsh	D 18
Eugene	B 6	Malin	D 17	Upper Rogue River	D 10
Forest Grove	A 1	Mary's Peak	B 2	Walla Walla, Wash	A 11
Fort Klamath	D 13	Medford	D 5	Wieser, Idaho	B 14
Fossil	A 6	Merrill	D 16	Woodruff Meadows	D 9
Fox	B 10	Mt. Hood	A 3		

PART II.

Distribution and Ecological Relations.

The state of Oregon is divided into two uneven portions by the high Cascade Range which reaches a maximum elevation of over eleven thousand feet at Mt. Hood. The western third has a broad central depression in which are three main river valleys, Willamette, Umpqua, and Rogue. These are separated by low mountain divides and the Rogue is separated from California by the much higher Siskiyou range. Between the valleys and the coast is the much dissected Coast Range. The eastern two thirds of the state is largely an arid plateau. The Blue Mountains cover a considerable portion of the northeast quarter of the state, and reach an elevation of over nine thousand feet in the Wallowa Range.

The natural vegetation areas of the state and localities mentioned are shown in the map (Fig. 3). On account of the diversity of habitats a discussion of the Orthopteran fauna can be facilitated by dividing it into three parts, namely, Western Oregon, the Alpine Cascade regions and Eastern Oregon.

WESTERN OREGON.

This area is shown on the map as the Douglas fir area. The western portion of the Coast Range and the west slope of the Cascades are entirely forested. In the central valleys where the annual precipitation is lower there were originally extensive prairies covering most of the large valley plains. A large part of this area is now under cultivation but the Orthopteran fauna has probably not changed much. The small streams are mostly bordered by deciduous forest containing Oregon ash (*Fraxinus oregana*), the broad leafed maple (*Acer macrophyllum*) and Garry oak (*Quercus garryana*) and other deciduous trees and shrubs.

The valley prairie may merge with the hill prairie extending over the south facing slopes to the summits of hills bordering the valley. More frequently the two are separated by an irregular strip of woods composed largely of Garry oak. This extends upward along the gullies and often forms a border also between hill prairie of the south slope and the fir forest on all other slopes. Part of this oak area is kept in a scrubby con-

dition by recurrent prairie fires. In the valley prairie and lower portions of the hill prairie are numerous thickets of wild rose, and poison oak.

In the virgin condition the heavy Douglas fir forests are inhabited by only one species of Orthoptera, the cave cricket, *Tropidischia xanthostoma* (Scudder) which has been found abundant under log bridges crossing the mountain streams. It probably also occurs in any natural dark cavities along the streams. *Neduba carinata* Walker also occurs in the fir forest along roads, in burns or wherever the forest is more open. It is more strictly a border species.

In the prairies Orthoptera are abundant. Since there is some difference between the fauna of the northern and southern parts of western Oregon the Willamette valley will be considered first. The following more strictly prairie species are universally present at the proper seasons: *Chorthippus curtipennis oregonensis* (Scudder), *Camnula pellucida* (Scudder), *Arphia saussureana* Bruner, *Melanoplus devastator* Scudder, *M. femur-rubrum* (De Geer), *M. mexicanus bilituratus* (F. Walker) and *Oecanthus nigricornis argentinus* Sauss. *Conocephalus fasciatus vicinus* (Morse) and *Acrydium granulatum* Wm. Kirby are found in more moist portions of the area. *Parcoblatta americana* (Scudder) and *Pristoceuthophilus pacificus* (Thomas) are found under boards, logs, stones and in gopher holes. The former is very common among rocks at the hilltops and has not been found in the valley plain. *Conocephalus occidentalis* (Morse) is found at the edge of prairies bordering the river in the valley plain. *Dissosteira carolina* (Linn), *Trimerotropis fontana* Thomas and *Gryllus assimilis* (Fab.) are more versatile and may be found either in prairie or in open woodland. *Melanoplus saltator* Scudder is found along the borders of woods, in open woodland, or among clumps of shrubs. *Trimerotropis suffusus* Scudder is found in hilltop prairies but on the slopes it remains fairly close to the woods. It is not found in the valley plain except at certain points in woods immediately bordering the river.

Another group is made up of those species associated with the deciduous woods or thickets. These include *Neduba carinata* living on the ground mostly where covered with deciduous dead leaves but also among more open fir forest or borders; *Oecanthus niveus* (De Geer), physiological race A,

mostly in ash and oak trees; *O. niveus*, race B, in thickets of rose, scrub oak and wild brambles; *O. californicus* Saussure in thickets containing a small species of rose used as a depository for the eggs; *Phaneroptera furcata furcata* (Brunner) mostly on small oaks.

On the gravel bars along the Willamette River two species that are more typical of the eastern desert regions are found, namely *Trimerotropis pallidipennis pallidipennis* (Burm.) and *Conozoa wallula* (Scudder). These strong flyers spread over into nearby fields but are not found far from the river. Where small plants are growing on the gravel the grouse locust *Telmatettix hesperus* Morse is found.

A few other species of this general region are of rare occurrence or irregular in distribution. *Melanoplus immunis* Scudder is found abundant in a meadow at the summit of Mary's Peak, at an altitude of about 4,000 feet, and on some of the lower hills. It is more common near the forest borders. *Podisma polita* Scudder is abundant on the same mountain but only on a steep slope of jumbled rocks overgrown with thimble berry in a small opening in the forest near the summit. A few specimens have also been found on other near-by mountains and hills near Corvallis. The occurrence of *Napaia aspasma*, *Steiroxys strepens* and *Ceuthophilus agassizii* near Corvallis has been previously mentioned. *Pristoceuthophilus celatus* (Scudder) is apparently rare about Corvallis. *Mymecophila oregonensis* Bruner was found in ants nests in a valley of the coast range west of Corvallis.

Most of the common species mentioned above range westward through the coast range. The prairies disappear but there are old burned areas, pastures and roadways where the prairie and border species find suitable conditions. Near the ocean the number of species and individuals is reduced. In a sand dune area near Newport only three species were found, *Melanoplus mexicanus bilituratus* in grassy places between dunes and *Dissosteira carolina* and *Trimerotropis suffusus* near wooded dunes.

The somewhat hotter and dryer regions of the Umpqua and Rogue River valleys of southwestern Oregon are inhabited by a larger number of species. All of the Northern species mentioned have been found in this region or have been recorded in literature from southern Oregon or Califonia except *Ceuthophilus agassizii*

and the two species mentioned below which are replaced in southern Oregon by closely related species. *Melanoplus saltator* is replaced south of Eugene by *M. validus calapooyæ* and this in turn is replaced further south by typical *validus*. *M. immunis* is apparently replaced by *M. rehni*, both hilltop species whose exact range is not known. These species occupy the same ecological niche as the species they replace, and species common to both regions show the same choice of habitat.

Species common in the southern valleys but not represented in the Willamette are *Dissosteira spurcata* Saussure and *D. venusta* (Stal), both strong flying prairie and woodland border species.

Other species of more local distribution that have been found are: *Oedaleonotus borckii borckii* (Stal), open field, Grants Pass; *Melanoplus bruneri* Scudder, fields, Drain, Grants Pass; *Arphia ramona* Rehn, wooded mountain ridges and rock outcrops near Ashland.

In the Rogue River Valley *Melanoplus devastator*, *M. femur-rubrum* and *Camnula pellucida* occurred in destructive numbers in 1922.

The writer did not have opportunity to collect in yellow pine-sugar pine area shown on the map (Fig. 3) lying west of the Cascade Divide in southern Oregon.

ALPINE AREAS.

On the heavily forested west slopes of the Cascade Range Orthoptera are most common in clearings, burns and along roads. Such places present about the same fauna as the coast range. In the higher valleys are many small natural prairies where Orthoptera are very abundant. These are probably developed from ponds or bogs. Their isolation and diverse conditions as to moisture and temperature tend to give them a more or less individual fauna. Few of these areas have been investigated and they offer an unusual opportunity for anyone interested in ecology or taxonomy.

On August 5, 1922 the writer visited a small prairie called Woodruff Meadows about thirty miles southwest of Crater Lake, at an altitude said to be about 2800 feet. While this can hardly be considered Alpine conditions it is similar to such areas found more commonly at higher altitudes. There was a striking zonation of the vegetation. The center contained some

surface water and was covered with a high sedge and large lupines. Surrounding this was a wide zone of damp ground with shorter swamp grasses, and another zone of dryer ground bordering the forest and covered mostly by herbs. In the central area the only abundant species was *Melanoplus bivittatus* (Say). In the middle zone *Chorthippus curtipennis oregonensis* was most abundant but this zone also contained many of the first species. At the eastern end of this zone was a crescent shaped dryer area of short grasses where *Camnula pellucida*, *Oedaleonotus borckii pacificus* (Scudder) and *Steiroxys strepens* were abundant. The latter was also found in grass clumps over most of the meadow except the central portion. The commonest species in the herb border was the red-legged *Melanoplus validus*, showing characters of intergradation between the three races previously discussed. On the south side of the meadow a shaded lobe with damp mossy ground and short grass, contained *Acrydium granulatum*, *Melanoplus lovetti* and *Steiroxys strepens*. The forest borders were dryer, with short grass or partly bare ground and there the common species were *Trimerotropis fontana* and *Cratypedes neglectus* (Thomas). *Napaia aspasma* (R. and H.) occurred along the southeast border.

Neduba carinata is common in more open parts of the Cascade forest slopes but apparently it does not extend to the higher alitudes of the divide. *Cyphoderris piperi* was found in the forest near Woodruff Meadows and at the timber line at Crater Lake. The writer heard an insect which was probably this species singing in trees at the timber line on Mount Hood. It was described from Mt. Rainer much farther north.

The isolated alpine meadows of the higher parts of the Cascade divide contain some species which are not found at lower altitude. These regions also offer a rich field for further investigation. In the meadows at Crater Lake the writer found *Bradynotes deplanata* Hebard and *Camnula pellucida* abundant in an area of short grass. *Trimerotropis suffusus* occurred on ridges in the same general area and *Circotettix shastanus* Bruner on and near rocky cliffs. The writer also has specimens of *Melanoplus alpinus* Scudder and *M. montanus* (Thomas) and has seen specimens of *Bruneria shastana* (Scudder), all collected by L. P. Rockwood in the Crater Lake meadows. A pair of the last species was collected by the

writer at the summit of Paulina Mountain, an isolated volcanic crater south of Bend. The lower portions of the meadow of Crater Lake where plants were waist high contained few Orthoptera. Alpine species of the Mt. Hood region include *Melanoplus oreophilus* Hebard, *Pristoceuthophilus cercalis* Caudell and *Prixocnemis oregonensis* Caudell. A specimen of the last species was collected by W. J. Chamberlin from a slab pile in Josephine County, at the western end of the Siskiyou Mountains. The writer has two specimens of *Acrydium acadicum brunneri* (Bolivar) collected by J. C. Bridwell at Cash Creek on the Santiam road and one collected by W. J. Chamberlin labelled Santiam National Forest.

EASTERN OREGON.

The territory east of the Cascade Divide includes the following natural vegetation areas: (1) The yellow pine forests of the eastern slope of the Cascades and adjacent plateau and of the Blue Mountains in the northeast, (2) the juniper woodland between the two yellow pine areas and in smaller areas to the south, (3) areas originally in bunch grass including the valleys and lower mountain slopes in the Northeastern quarter, (4) sage brush desert including most of the southeastern quarter and a part of the Columbia Valley, (5) isolated marsh or tule areas the largest of which is around Klamath Lake.

The Orthoptera of eastern Oregon have been collected by the writer only on occasional trips for other purposes and consequently the species discussed represent only a part of the rich Orthopteran fauna of this region.

The yellow pine forests contain many species common along forest borders in western Oregon. They are most common in the open spots but on account of the more open nature of the pine forest are more generally distributed here than in the fir forest. The common species are *Trimeroptopis suffusus*, *T. fontana* and *Cratypedes neglectus*, the last more common at higher altitudes. *Neduba carinata* and *Melanoplus validus pinicola* occur in the Cascade area but have not been found in the Blue Mountains. *Camnula pellucida*, *Conozoa wallula* and *Dissosteira carolina* are found in the small prairies that occur in the pine forest. A specimen of *Dissosteira venusta* from Klamath Lake is probably from such a situation also.

The second, third, and fourth natural vegetation areas can be discussed together for they all represent desert or semi-desert conditions, and all contain a large proportion of various kinds of sage brush. A list of the identified species in the writer's collection with localities follows:

Parabacillus coloradus (Scudder). Boardman.

Acrydium granulatum Kirby. LaGrande. On a mountain slope where seepage modified the moisture conditions.

Pseudopomala brachyptera (Scudder). Hermiston.

Amphitornus coloradus (Thomas). La Grande, Hermiston.

Alpha occipitalis occipitalis (Thomas). Ontario.

Alpha occipitalis cinerea (Bruner). Bend.

Orphulella speciosa (Scudder)*. Ontario, small marsh.

Chorthippus curtipennis (Harris). Jordan Valley. (George Orr) Probably from meadows.

Agneotettix deorum (Scudder). Hermiston, La Grande, Ontario.

Psoloessa delicatula (Scudder). Burns. (B. G. Thompson).

Aulocara elliotti (Thomas). Merrill, Burns, La Grande, Ontario, Jordan Valley.

Arphia pseudonietana (Thomas). Baker, Freewater (near Walla Walla, Wash.), La Grande.

Camnula pellucida (Scudder). Merrill, Silver Lake, Hermiston, Walla Walla, Wash., La Grande, Halfway. Found where grass grows abundantly.

Xanthippus corallipes buckelli Hebard. Steins Mtns. and Plush (W. J. Chamberlin), La Grande, Fox Prefers hills.

Dissosteira carolina (Linnaeus). Hermiston, statewide.

Spharagemon aequale (Say). Fossil (L. P. Rockwood), Boise, Idaho (A. L. Lovett).

Trachyrhachis kiowa kiowa (Thomas). Ontario.

Metator pardalinus (Saussure). Ronan Mt. Wash. (W. C. Handlin)

Conozoa wallula (Scudder). Hermiston, Ontario, Baker, Merrill.

Trimerotropis fantana Thomas. Hermiston, La Grande, Baker, Burns. Near or among trees.

T. pallidipennis pallidipennis (Burmeister). Hermiston, La Grande, Baker, Ontario, Merrill.

T. latifasciata Scudder. Ontario.

T. caeruleipennis Bruner. Tule Lake (near Malin, M. M. Reeher) Pasco, Wash. (A. L. Lovett).

T. cyaneipennis Bruner. Hermiston. Found on a small sage covered hill.

T. suffusus Scudder. Burns, Dufer, La Grande, Ontario. Found most common in or near woodlands.

Circotettix undulatus (Thomas). Hood River, Bend, Merrill, Hermiston, Baker. Found on open hilltops or rock outcrops.

Schistocerca venusta Scudder.[7] Hermiston. Taken in a garden; probably a river border species.

[7]Assignment questionable due to need of revisionary work in genus.

Hesperotettix brevipennis pratensis Scudder. La Grande, Ontario.

Melanoplus bivittatus (Say). Ontario, Halfway, Baker. From irrigation ditches; not a desert species.

M. femur-rubrum femur-rubrum (De Geer). Hermiston, Ontario, Malin.

M. mexicanus bilituratus (Walker). Hermiston, Baker, La Grande, Malin, Ontario.

M. packardi packardi Scudder. Hermiston, La Grande, Ontario.

M. cinereus cinereus Scudder. Dufer, Hermiston, Baker, Wieser, Idaho.

Bradynotes deplanata Hebard. Merrill. Among sage brush near marsh.

Phoetaliotes nebrascensis (Thomas). La Grande. From mountain slope under more moist conditions.

Oedaleonotus enigma (Scudder). Hermiston, La Grande, Baker, Wieser, Idaho.

O. borckii orientis Hebard. Merrill.

Phaneroptera furcata furcata (Brunner). Dufer, female nymph (F. H. Lathrop). From an irrigated area.

Anabrus simplex Haldeman. Klamath Falls, (H. F. Wilson).

Apote notabilis Scudder. Heppner (N. Currin).

Gryllus assimilis (Fabricius). Ontario.

Oecanthus nigricornis argentinus Saussure. La Grande. Most common in weedy places or praries, but also on rabbit brush

Oecanthus californicus Saussure. La Grande. In thickets of wild rose in mountain gully.

In the marsh areas of eastern Oregon several species of grasshoppers are extremely abundant. *Camnula pellucida* frequently occurs in such numbers as to destroy large areas of vegetation. This is the earliest of the common species to mature. On Aug. 9, 1922 the writer found *Conozoa wallula* and *Dissosteira carolina* more abundant than Camnula in the drained Tule Lake region south of Klamath Falls. *Melanoplus mexicanus bilituratus* was also found there in destructive numbers. Some of these species may have migrated in from surrounding deserts. In the Upper Klamath Marsh on Aug. 11, and 12, *Camnula* was found in destructive numbers but was disappearing rapidly. Other species found there were *Acrydium granulatum*, *Chorthippus curtipennis*, *Melanoplus mexicanus bilituratus* and *M. borealis palaceus*.

ACKNOWLEDGMENT.

The writer is indebted to A. N. Caudell, J. A. G. Rehn and Morgan Hebard for assistance in the identification of species.

LITERATURE CITED.

(1) **Caudell.** Jour. N. Y. Ent. Soc. 12: 47, 1904.
(2) **Fulton.** Ann. Ent. Soc. Amer. 18: 363-383, 1925.
(3) " Ore. Agric. Exp. Sta. Bul. 223: 1-20, 1926.
(4) " Iowa State Jour. Sci. 1: 43-61, 1926.
(5) " Ent. News 39: 8-11, 1928.
(6) " Pan-Pacific Ent. 5: 175-180, 1929.
(7) **Hebard.** Trans. Amer. Ent. Soc. 46: 355-403, 1920.
(8) " Proc. Acad. Nat. Sci. Phil. 81: 303-425, 1929.
(9) **McNeill.** Proc. U. S. N. Museum 23: 393-449, 1901.
(10) **Riley.** Sixth Ann. Rpt. Insects of Mo., p. 165, 1874.
(11) **Scudder.** Proc. U. S. N. Museum 20: 1-421, 1897.
(12) " Proc. Davenport Acad. Nat. Sci. 7: 157-205, 1899.
(13) **Shantz** and **Zon.** Atlas of American Agriculture, Section E, Natural Vegetation. U. S. Dept. Agr. 1924.

A FOSSIL ARACHNID FROM THE LOWER CARBONIFEROUS SHALES (POCONO FORMATION) OF VIRGINIA.

H. E. Ewing,
United States Department of Agriculture.

A few years ago Dr. David White, for many years chief geologist of the United States Geological Survey, found what appears to be the oldest fossil land arthropod yet taken in North America. It is an interesting specimen not alone because of its antiquity, but because of the important taxonomic relations of the extinct order to which it belongs. This group, the Anthracomarti, together with that other very rare group of both living and extinct forms, the Ricinulei, bridge over the otherwise very wide gap between the spiders and the mites and help us construct what is believed to be a more rational system of classification for the Arachnida. The Anthracomarti are related to the Ricinulei in having the tergites of the abdomen divided by two longitudinal grooves and to the extinct Phalangiotarbi in having the first pair of legs pediform.

The living Ricinulei are represented by a few living species found only along the west coast of equatorial Africa and in certain regions of the American tropics. Although a very ancient group, with many generalized characters, the Ricinulei are peculiar in having the pedipalps fused at their bases.

The order Anthracomarti, to which Dr. White's Lower Carboniferous specimen belongs, may be diagnosed as follows: Capitulum and thorax fused. Abdomen segmented; abdominal tergites divided laterally by one or two longitudinal sutures on each side; "operculum" present and representing, probably, the eleventh segment. Cheliceræ not yet observed. Pedipalps leglike. Legs with movable coxæ.

This order is represented by a considerable number of specimens from the Carboniferous formations of both the Old and New Worlds.

Trigonomartus whitei, new species

Exposed parts of specimen include most of the cephalothorax and all of the abdomen except a small anterior portion of each lateral border. No part of any one of the legs is exposed.

Cephalothorax roughly triangular, but the lateral margins are somewhat outcurved. Surface very coarsely sculptured. Near the apex there is a rather deep impression of the ventral part of the hood.

Abdomen about as broad as long and broadly rounded behind. Longitudinal grooves, dividing tergites, very distinct; each is situated about half the distance from the lateral margin to the median line, and each is curved in a similar manner to that of the lateral margin except near the posterior end. After the grooves cross the line between the last and next to last tergite each curves strongly outward to meet the lateral margins of abdomen at a slight distance from the vertex. In addition to these two longitudinal grooves there is a pair of longitudinal ridges on the central area of abdomen. Each originates near the abdominal base in a prominent boss, or tubercle, and passes backward in a straight line, parallel to the median line, to as far as the front margin of last tergite.

Tergites eight in number and all except the first with lateral sections. Tergite I with a recurved anterior margin and an almost straight posterior margin, and not extending across the abdomen. Middle sections of tergites II and III subequal and with margins about straight. Middle sections of tergites IV-VII with margins recurved. In width they decrease from IV to VII. Middle section of tergite VIII (the last tergite) about as broad as long, lateral margins strongly incurved, posterior border pointed at median line. The integument of the middle area of abdomen is coarsely sculptured.

Lateral sections of tergites (pleural plates of some authors) large, the lines between them being procurved except for the last. All except the last are quadrangular; these are subtriangular.

Length of cephalothorax, 3.00 mm.; width, 3.25 mm. Length of abdomen, 6.25 mm.; width, 5.50 mm. Total length, 9.25 mm.

Type locality.—Allegheny, Virginia.

Type.—In collections of United States Geological Survey.

Described from a specimen taken by Dr. David White, of the United States Geological Survey, from the Pocono formation of Virginia. Dr. White gives the following data in regard to the specimen: "It was collected by me from the shales adjacent

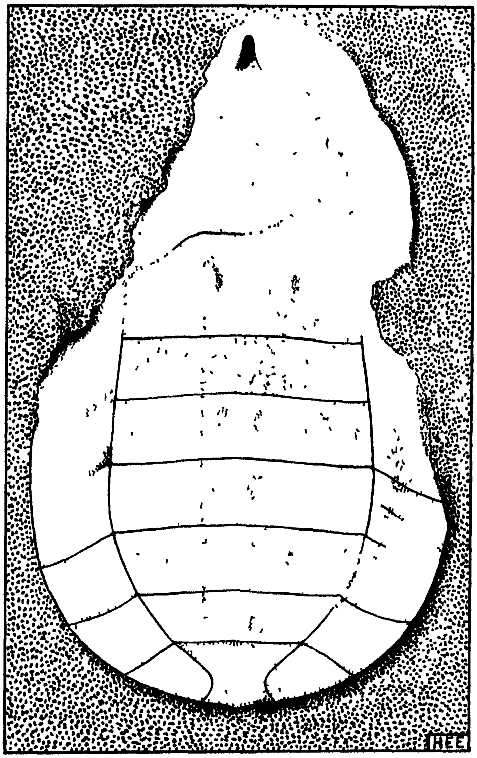


FIG. 1. *Trigonomartus whitei*, new species, × 10. Drawn as exposed in shale.

to a thin coal outcrop in the lower part of the Pocono along the road over the ridge and not far from the farmer's house near the west end of the so-called Lewis tunnel, which is the first tunnel on the C. & O. Railway east of Allegheny, Va. The specimen was collected May 17, 1924, and is accompanied by a land flora of the type associated with the formation of coal, and therefore is to be regarded as a lowland or swamp flora."

A CONTRIBUTION TO THE KNOWLEDGE OF THE BIONOMICS OF BREMUS AMERICANORUM (FABR.). (HYMENOPTERA).

THEODORE H. FRISON,
Illinois State Natural History Survey, Urbana, Illinois.

A. INTRODUCTION.

This paper is the third of a series of papers dealing with the biology of species of bumblebees found in Illinois. In the first paper (1928), the salient features of the bionomics of *Bremus bimaculatus* (Cresson) were recorded in a more or less detailed manner and much information presented regarding methods and technique. The second paper (1929) deals with the biology of *Bremus impatiens* (Cresson). For details regarding how much of the data used in this paper were secured, the reader should consult my two previous papers of this series, particularly the first one of 1928.

B. SYSTEMATIC POSITION.

Bremus americanorum (Fabr.) is one of four North American species of bumblebees belonging to the subgenus *Fervidobombus* Skorikov (1922) of the family *Bremidæ*. Four species—*americanorum*, *fervidus*, *californicus* and *sonorus*—have been placed in this subgenus because of numerous morphological characters common to all of them. Together with the subgenus *Subterraneobombus* Vogt (1911) they form a section of the bumblebees called *Odontobombus* Krüger (1917). My unpublished studies of the biology of *B. fervidus* and the writings of others show that this species of bumblebee has habits very similar to those of *B. americanorum* as now recorded. From this fact and the common possession of certain structural characters it is predictable that the most essential fundamentals of the biology of *B. sonorus* of the southwestern states and *B. californicus* of the western states will conform with that of *B. americanorum*.

C. Specific Life History Studies.

During the course of my studies of bumblebees, dating from 1910, I have had under observation a large number of colonies of this species and obtained much information concerning the behavior of the adult bees and various phenomena relating to their life history. In fact, I have examined and studied so many colonies of *B. americanorum* that it would be both tedious and poor economy of print and time to discuss each of them in detail. Instead, I have chosen to present for record a short account of but four of them; two of these being colonies which were studied in much detail in order to secure comparative data relating to the development of the immature stages.

1. Experiment 16, 1917.

This colony was started in an artificial domicile which I buried in the ground in the University Woods near Urbana, Illinois, on April 17, purposely for attracting the queens (Frison, 1926a). The first intimation I had that the domicile was occupied was on June 11, when a hasty examination revealed that the dried grass in the nest had been somewhat rearranged and packed down. About a week later I slightly jarred the domicile to discover if it was occupied and the excited buzzing of a queen which followed gave ample evidence of my good fortune. When the domicile was next examined, on July 11, the queen was not in the nest. At this time the larvæ were rapidly developing in their cells and the groove in which the queen rested when brooding on the incipient comb—similar to that I have illustrated for *B. impatiens* (Frison, 1927a)—was very noticeable. It was expected, but none the less interesting, too, to find a small honey-pot near the entrance of the nest and about one-half an inch removed from the brood; a characteristic feature of the recently started nests of all species of bumblebees as yet discovered and probably a distinguishing biological peculiarity of this genus of bees.

On July 27, I removed the domicile from its original position and placed the nest in an observation box where I could better study the development of the immature stages. At this time the comb had greatly increased in size and the nest contained the mother queen and four workers. It is probable that three other workers were absent from the nest when it was removed because there were seven empty cocoons in the comb. In addition to the cocoons from which the adult workers had emerged, the comb of July 27 consisted of three cocoons from which the adults had not emerged, three groups of larvæ in various stages of development, and two egg cells. One of the egg cells contained three eggs and the second held five eggs.

During the next few weeks the growth of the comb was rapid and every few days additional egg cells were constructed and eggs laid in them by the mother queen. These egg cells were made on the tops, between, or on the sides of the cocoons. As the season progressed there was a noticeable tendency on the part of the queen to lay a larger number of eggs in a single cell; one egg cell containing on August 17 as many as thirteen eggs in marked contrast to the two to five eggs laid in a cell when the comb was small. The eggs were always laid contiguous to one another and in a more or less horizontal plane. One of the striking features of the nest of this species was the occurrence of wax-pollen cup-shaped structures on the sides of groups of small larval cells which were made just about the time the larvæ emerged from the eggs. On August 29, two of these wax-pollen cups were found attached to the side of one small group of larval cells in the bottom of each there was a small amount of fresh pollen. As the larvæ became larger each of them occupied a definite position beneath the wax-pollen envelop covering them and the wax-pollen cups were much enlarged. When the larvæ spun their cocoons these enlarged cups, or rather pollen pots as they now might be called, were necessarily separated from the larvæ and one might easily overlook the fact that they first originated on the side of groups of small larval cells. As the comb developed in size these large wax-pollen pots were used for the storage of pollen.

The first adult to emerge after the nest was placed in an observation box was a small worker or sterile female, on July 27, and additional workers henceforth appeared from time to time. An important point in connection with a discussion of the production of queens is the fact that a marked increase in the size of the workers was noticeable as the season advanced. Three very large workers emerged as late as September 17. My notes show that a total of thirty-one workers, nine queens, and seven males were produced by this colony while it was under my observation. The first males emerged from their cocoons (Figure 5) on September 19 and the first queens (Figure 5) on September 23. The old mother queen lived until October 9, thus rounding out a life span of at least a year. In keeping with life in general she became very feeble during the last few days of her existence; in sharp contrast to the energetic and tireless individual of a few months before.

Six days after I began a detailed study of this colony, the bees were allowed to forage for pollen and nectar. The workers soon took advantage of their freedom but the old mother queen never left the nest. It should be mentioned that the workers in this nest were exceedingly vicious and that it was necessary to remove them each time the comb was examined to avoid being stung. As soon as the workers were returned to their nest some of them would immediately proceed to cover the comb over again as best they could with the materials which were available in the nest-box. Mention has already been made of the storage of pollen in special wax-pollen pots. The surplus honey, however, was stored in empty renovated cocoons which were usually partially capped with a lid of wax-pollen composition.

2. Experiment 22, 1919.

A few notes are presented regarding the history of this colony because the nest was found so early in the season that it illustrates the manner in which the comb is started by the queen under natural conditions. I accidentally happened upon the nest in the Brownfield Woods, near Urbana, Illinois, on June 20. As far as could be determined at the time, the comb was not started in an old mouse nest, but simply

Figure 1. Portion of the comb of *Bremus americanorum*, showing: *a*, small wax-pollen pocket on the side of a cell containing small larvae; *b*, similar pocket which has greatly increased in size and is equivalent to one of the pollen pots.

in a small bundle of leaves which had settled in a slight depression on the ground among bits of decayed wood. The queen was the only bee found in the nest and the size of the comb and lack of empty cocoons was sufficient proof that no workers had been produced. In fact, I found the comb almost at its very inception; something which rarely falls to the lot of a student of the habits of bumblebees.

In the nest there was found the characteristic wax-pollen honey-pot, ten millimeters in height and twelve millimeters at its greatest width. Scarcely ten millimeters from this storage pot was a wax-pollen lump, thirteen millimeters in length, five millimeters in width, and six millimeters in height. On this lump of wax and pollen composition (prin-

cipally of pollen) there were several cells containing eggs. For fear of causing the queen to desert her eggs, these cells were not closely examined to ascertain the number of eggs in each. As a result I have no record of the number of eggs they contained. Certainly, however, judging by the size of the egg cells the number of eggs in each cell was small.

After examining the nest it was brought to the laboratory and placed in a small observation box with the queen. Much to my delight this transference of so young a nest was performed without causing the queen to desert her eggs. On June 26, young larvæ were found in the incipient comb. Several cocoons were found in the nest on July 5 and the first worker emerged on the ninth of July. This colony was under observation for some time after this latter date but since it was not subsequently studied in detail and provided no unusual data its further history is not presented.

3. Experiment 28, 1919.

On June 29, I removed to the laboratory for observation a nest of *B. americanorum* which was situated in a mouse nest a few inches below the surface of the ground. Six days previous to this date, a queen was observed to enter this nest but the nest was not examined at that time. On the day it was removed the nest contained the mother queen, two workers, five cocoons containing pupæ, two brood clusters, two groups of egg cells containing a total of nine eggs, and three empty cocoons. The presence of three renovated cocoons, one containing pollen and two honey, was rather indicative that one worker was foraging when the nest was removed. No wax-pollen honey-pot separate from the comb was found in the nest when it was opened, but undoubtedly the growth of the comb had led to its destruction or its incorporation with the rest of the comb.

Soon after the nest was placed in an observation box, the workers proceeded to put the nest in order by removing from the comb all particles of soil which had fallen onto it when the nest was removed and covered the nest with grass. On this same date a record was started of the development of the immature stages. During the next few days several small workers emerged and these soon busied themselves in helping with the work. As an example of economy it was interesting to observe that the wax and pollen were removed from two cocoons soon after they were spun and transferred to a place where they were more needed. Three days after the colony was placed in an observation box another egg cell was constructed and five eggs laid in it. Mention should be made of the fact that the mother queen and workers greatly resented being disturbed and that this queen was one of the most aggressive bumblebee queens I have ever had under observation.

During the first two weeks in July several things happened which are worthy of record. Soon after the appearance of small larvæ, cup-shaped, wax-pollen structures were built on the sides of the cells containing them. The purpose of these cup-shaped structures was not discovered until a later date. On one occasion when examining an

egg cell in order to determine whether or not the eggs had hatched I accidently mutilated the cell walls more than was necessary. A worker which chanced upon this cell, immediately seized and ate one egg which was particularly exposed. One day two dead larvæ and one pupa were dragged from the nest by the workers. In order to remove the pupa it was necessary for the workers to open the cocoon. It seems evident from this that the workers are capable of distinguishing between healthy, diseased, or dead larvæ and pupæ. On July 7, I observed that sometimes grains of pollen are incorporated into the wax-pollen covering

FIGURE 2. Comb of *Bremus americanorum*, showing: *a*, cocoons; *b*, cocoons used for the storage of honey; *c*, wax-pollen pockets on the sides of cells containing small larvae; *d*, egg cell; *e*, cells containing larvae. July 20.

of the brood clusters directly from the pubescence of the bee. On this date a worker returning from foraging in the field was observed to enter the nest box (the colony was released on July 5). The pubescence of this worker was completely dusted with pollen grains, but the corbicula were almost bare. With scarcely any hesitation this worker immediately took a position on a group of small larval cells and while standing there thoroughly scraped the grains of pollen from her body onto the wax-pollen covering surrounding them. These grains of pollen were then incorporated into the wax-pollen covering by other

workers. Twice during the early part of July I saw adult flies of *Brachycoma sarcophagina* (Townsend) in the nest and removed them.

The last half of July the comb increased in size at a rapid rate and a photograph taken of this nest on July 20 is shown in figure 2. The mother queen at this time, though apparently as active as ever, plainly showed the effects of her ceaseless industry by the loss of much of the pubescence on the dorsal parts of her thorax and abdomen. She still continued to produce a considerable amount of wax, which could plainly be seen where it had exuded from her abdomen. More eggs were laid now than ever before and from nine to fourteen eggs were deposited in a single cell. This was a marked increase over the number of eggs which were laid in the cells during the early history of the colony. The eggs continued to be contiguous to one another in a more or less horizontal plane. When the eggs first hatched all of the resulting larvæ necessarily occupied the same cell. As the larvæ increased in size each of them occupied its own particular position under the wax-pollen brood covering and the number of larvæ in the group could be readily determined by counting the number of distinct swellings or raised portions. Before the larvæ attained full size a further separation of the larvæ occurred; due to the fact that the larvæ then necessarily spun a considerable amount of silk which held intact the walls of the cells covering them. Upon several occasions I accidentally dislodged healthy larvæ from their cells and they were always carried out of the nest by the worker bees.

The construction of wax-pollen cup-shaped cells on the sides of young brood clusters still continued during the latter part of July. It became evident, also, that as the larvæ grew these cells were often enlarged and eventually were used as receptacles for the storage of pollen. Pollen was scarcely ever found in them, however, when they were small. Workers continued to emerge during the last of July and it was quite noticeable that most of them were much larger than those produced during the early part of the season. Recently emerged workers appeared frightened whenever the nest was examined and oftentimes tried to hide between and among the cells of the comb. A couple of days after emerging, however, when the normal color of their pubescence was completely attained, no difference was noticeable between them and older workers; all having a vicious and aggressive disposition in common. On very hot days some of the workers frequently took a position near the entrance of the nest and fanned the air with rapidly vibrating wings. The origin of this ventilating of the nest, the basis of Goedart's (1685) celebrated fable of a trumpeter bumblebee, offers considerable food for speculative thought. Bridges of a stiff wax-pollen composition were constructed in several places in the nest to connect the comb with the side walls of the nest. These structures served admirably as anchoring supports for the comb.

The first of August two experiments were tried the results of which well illustrate the temperament of the bees of this species. First a worker of *B. auricomus* (Robt.) was placed in this nest. Eight workers of *americanorum* immediately attacked the alien species and within

three minutes it was dead as a result of being stung by the bees. Interested to see the results of a reversal of this experiment, a worker of *americanorum* was placed in a nest of *auricomus*. The introduced worker was not attacked and ran about over the comb with impunity. On August 9, the first young queens of the season partially cut the tops from their cocoons and emerged. Although the history of this colony was not followed closely during the remainder of the season some observations were made which merit record. The old queen was found dead in a corner of the nest-box on September 11. On September 24, several egg cells containing eggs were found on cocoons. These were undoubtedly of worker origin. At nine o'clock in the evening on September 24 I brought the colony into the house where it was warm. The next morning a worker returned to the place from which I had removed the nest, indicating that the worker had remained out-of-doors during the night. There still remained alive in the nest on October 3 twenty-three workers, and eight queens and four males which had emerged since the nest was brought into the house. Under

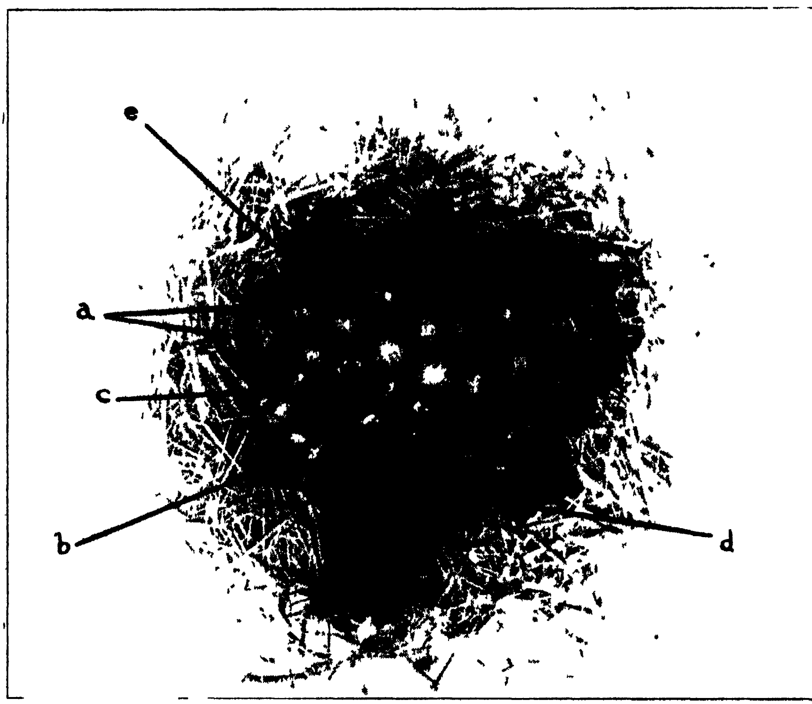


FIGURE 3. Comb of *Bremus americanorum*, showing: *a*, cocoons; *b*, wax-pollen pot on the side of a cocoon; *c*, cocoons used for the storage of honey; *d*, wax-pollen pocket on the side of cell containing small larvae; *e*, egg cell. August 15.

the influence of warm conditions two workers lived until the end of October, and a couple of males emerged as late as October 10.

4. EXPERIMENT 29, 1919.

On September 13, I removed to the laboratory a colony of *Bremus americanorum* which was situated in one side of a clay enbankment near White Heath, Illinois. The nest itself was about ten inches from the surface of the ground and reached by a tunnel. The opening to the tunnel was slightly below the level of the nest and accordingly surface water could not flow down into the nest by way of the tunnel. Judging from the interior of the nest it must have been made originally by a mouse and then selected by a searching bumblebee queen. The fact that the comb was slightly over one foot in diameter when found is indicative that the original cavity was enlarged by the bumblebees as the comb grew in size Additional proof of this supposition lies in the fact that some small pellets of clay were found near the entrance to the tunnel and many more had rolled down the side of the bank. This observation supports a statement made by Wagner (1907) which two recent students of the biology of bumblebees (Sladen, 1912, and Plath, 1924) have failed to verify.

At the time the nest was removed an average of one worker per minute was returning to the nest with provisions of pollen and nectar. The nest contained ninety-eight workers of various sizes, seventy-one young queens, twenty-five males, four eggs, ten larval cells, eighteen wax-pollen cells containing pollen, and one hundred and thirty-four cocoons filled or partially filled with honey, besides two hundred and fifty-six cocoons containing larvæ and pupæ. The old queen was not discovered. The comb of this nest was so large that I had to divide it into two parts and place each half with an equal proportion of bumblebees in separate observation boxes. A brief description of this colony has been given here because of its enormous size and because of several interesting experiments which centered around it.

Three days after placing the comb and bees in observation boxes I allowed the bees the privilege of foraging for themselves. Advantage was taken of the situation thus created and a study made of the orientation flight of bees leaving the nest for the first time; or at least the first time in this location (20 miles from former nest site). The results of these observations will be presented elsewhere. During the latter part of September a male and queen were observed *in coitu* in one of the nest boxes. Evidently in this species mating sometimes occurs inside of the nest. Proof that the queens of this species sometimes return to the nest after leaving it was provided by an observation of September 23 when I saw a young queen return to the nest from the field. Although but few workers emerged during the latter part of September, numerous queens and males emerged in abundance and continued to do so until Cctober 8. On this latter date there still remained alive in one-half of the nest twenty-eight queens and four males. When the nest was last examined on November 11, the few bees which had remained in the nest were dead.

D. Biological Summary.

1. Resumé of Literature.

The first reference in literature concerning the habits of this species is by Cresson (1863). This author recorded the capture of a nest of *B. pennsylvanicus* (= *americanorum*) on September 11 and says "It contained six females, thirty-four workers, and twenty-one specimens of *Apathus elatus* Fabr. (= *americanorum*), all males. No males of *B. pennsylvanicus* were found in the nest." The discovery of this nest was important as it threw some light on the status of *B. nidulans* Fabr. Among the males of the so-called *A. elatus*, "some had the anus entirely black, some black tipped with fulvous or yellow, some entirely yellow and others entirely fulvous." The specimens with the apical abdominal segments fulvous are undoubtedly, as Cresson thought, the *B. nidulans* of Fabricius. Cresson erred, however, in considering these males to belong to *Apathus* (= *Psithyrus*), for they were the true males of what he called *B. pennsylvanicus*. A short time later Putnam (1864) recorded finding on June 6 a queen of this species with her first larvæ and eggs.

The next biological information given in literature was published about thirty years after Cresson's paper when Robertson (1890) recorded the finding of a nest of *B. americanorum* on August 20. This nest contained one queen, one hundred and twenty-one workers, and two males. Two other nests of this species were examined by Robertson on September 9. One of these contained ten queens, forty-six workers and ten males, while the second nest contained nine queens, fifty-one workers and one male. On this same date Robertson saw a male, similar to those taken in the nests, copulating with a queen of *americanorum*. Robertson was convinced by his discoveries that the males he found in these nests (*Apathus elatus*) were the true males of *B. americanorum*. Further, he recognized the fact that two distinct species were confused under the same name. One of these he referred to *B. americanorum* and the second to *B. pennsylvanicus*. The last-mentioned species was later described by Robertson (1903) as *B. auricomus*.

Contemporaneous with Robertson's first paper there appeared an article by Coville (1890) who also advanced the idea that the males found by Cresson in the nest of *B. pennsylvanicus* (= *americanorum*) were the males of this bumblebee and not *Apathus* (*Psithyrus*). In spite of the accumulated evidence, Ashmead said in discussing Coville's article that he "would hardly be willing to accept these conclusions as final until the insects had been reared from the egg." The fact that I have reared these males from *Bremus* eggs, completes the chain of evidence, if additional facts are needed. With the knowledge that we now possess concerning the structure of *Psithryus* and *Bremus* such complete evidence as demanded by Ashmead is no longer required to satisfy ourselves as to the generic relationships of the bees found in the same nest. Such data are greatly needed, however, to substantiate

our ideas regarding the proper association of males and females of several species of *Pratobombus* occurring in the Western States. It should be mentioned at this point also that *Apathus elatus* was erroneously used by older writers as the name for the males of several species of *Bremus*.

The next note on the habits of this bee was published by Banks (1902), who recorded that he found a specimen of this species sleeping on the under side of a wild carrot flower. He stated that the mandibles were not used in maintaining this position as oftentimes happens with certain other Hymenoptera. Four years later Fairchild and Barrett (1906) published a joint note on the copulation of *Bombus fervidus*. According to Franklin (1913), the species involved was *B. americanorum* which, based on a study of the figures, is also my opinion. Fairchild and Barrett give the best description of the mating habits of bumblebees to be found in our literature. Their observations were made at Arlington, Virginia, about October 13.

During the last twenty years our knowledge concerning the biology of this species of bumblebee has received marked impetus—due to the contributions of Franklin, Howard, Jackson, Frison, Rau and Plath. Franklin (1913) states that the nests of this species which he found were "usually built in deserted mouse nests on the surface of the ground," but that sometimes their nests are subterranean. The largest nest this author found contained one queen, fifty-three workers, twenty-three males, and seventy-eight cells, eighteen of which were queen cells. He also recorded finding a large "roll of pollen" which weighed 3.59 grams. The substance of the note by Howard (1918) is the recording of a nest of this species which was found in a bulky sparrow nest "twenty or more feet from the ground." Data concerning the time of appearance of the various castes in the vicinity of Washington, D. C., has been contributed by Jackson (1920). The first of the two papers by Rau (1922) records the finding of one nest of this species at Eureka, Mo., on July 12, which was in an old paint bucket hanging above the floor. Previous to its occupation by the bumblebees it had been occupied by wrens. A second nest was discovered by this same author in a "sack filled with straw, lying on the floor of an abandoned club-house." The second paper by Rau (1924) gives data regarding the homing instincts of this species and other information concerning their habits of interest. His experiments conclusively show, in agreement with my unpublished data, that bumblebees are not guided by any unknown sense in returning to their nests.

The papers by Plath present much information of a varied and most interesting character, although none of them deal alone with this species. In his first paper dealing with our subject, Plath (1923a) records his failure to induce queens of this species to start colonies in confinement; an experience which agrees with the results of the writer's experiments to date. In a second paper (1924) there is a brief mention of the incompatibility of *americanorum* with its closest relative even under exceptional conditions. In subsequent papers this same author has recorded the location and contents of a nest found near Boston (1927a);

the fact that *americanorum* is a "pocket-maker" and other information concerning the feeding of the larvæ and nest economy (1927b); and data regarding seasonal adjustments (1927c)

2. Anthophilous Habits

The number of records of the flower visits of this bumblebee are very large and prove this American bumblebee to be polytropic as is the case with all others thus far studied in detail. These records have been

FIGURE 4 Comb of *Bremus americanorum* from a side view showing the growth-form of the comb and. *a*, wax-pollen pots; *b*, cocoons of queens August 15

summarized by Lutz and Cockerell (1920) with the exception of the following:

Robertson (1891–1896): *Triosteum perfoliatum, Cephalanthus occidentalis, Lobelia leptostachys, Lobelia syphilitica, Lobelia cardinalis, Campanula americana, Verbena bastata, Verbena urticaefolia, Martynia proboscidea, Trifolium pratense, Baptisia leucophaea, Isopyrum biternatum, Gaura biennis, Oenothera biennis, Oenothera fruticosa, Ludwigia alternifolia, Hydrangea arborescens, Sida spinosa, Abutilon avicennæ, Hibiscus lasipcarpus, Oxalis violacea, Spiranthea gracilis, Orchis spectabilis, Astragalus mexicanus, Cercis canadensis, Amphicarpaea pitcheri, Cassia chamaecrista, Cassia marilandica, Desmodium paniculatum, Desmodium dillenii, Desmodium caspidatum, Desmodium canadense, Camassia fraseri.*

Jackson (1920): *Chrysopsis mariana* and *Cirsium lanceolatum.*

3. Duration of the Developmental Stadia.

The present deductions regarding the developmental stadia are derived from tables similar to those presented in the first article of this series (Frison, 1928). Because of the extensiveness of these tables and for the sake of economy they are not presented. It may be of interest to add, however, that the colony in Experiment 16, 1917, was examined fifty-three times from July 27 to September 29 in order to secure the data here briefly summarized and the colony in Experiment 28, 1919, was subject to examination fifty-four times during the interim of June 29 to August 9.

As in the case of all species of bumblebees thus far studied, the egg stage is the shortest in duration and lasts about four and one-half days for queens, workers or males. The larval stage is subject to considerable variation. For the workers this period varied from eight to eighteen days and about eleven to twelve days was the commonly encountered period. The known larval period of one group of larvæ which produced males was twelve days and similarly for the queens one group required thirteen days in the larval stage. The pupal stage varied between six and nine days for the workers, seven to ten days for the males, and ten to fourteen days for the queens.

Correlated with the variation found in the duration of the various stadia there was found a variation in the duration of the complete developmental cycle. The workers required between twenty-one and thirty days to reach maturity after the eggs were laid, the queens twenty-nine to thirty-five days and the males about twenty-five days. It is significant (Frison, 1927) that large workers required more time to complete their development than did the smaller workers.

4. Seasonal Appearance of the Castes.

When compared with certain other species of bumblebees the majority of the queens of *americanorum* leave their hibernacula rather late in spring. I have never found the queens flying in the vicinity of Urbana, Illinois, in the month of March. Occasionally they may be seen on the wing during the latter part of April, but the great majority of them are first seen in May. It is not uncommon, also, to find the queens flying during the last of June at a time when the colonies of *B. bimaculatus* are well advanced (Frison, 1928). The earliest records which I have of the capture of these queens in Central Illinois for a period of years are: May 5, 1911, Champaign, Illinois; May 4, 1914, Urbana, Illinois; April 23, 1915, University Woods, Urbana, Illinois; May 24, 1916, Urbana, Illinois; April 23, 1917, White Heath, Illinois; May 22, 1919, Urbana, Illinois; and May 8, 1920, Oakwood, Illinois.

According to the data presented in literature, those of Experiments 16, 28, 29, and those given under a discussion of the size of the colonies and mating, the great majority of the young queens are produced during the last of August and September. Many queens emerge even as late as October. In correlation with the production of young queens, the males are usually produced in late summer and fall. Instances of course

do occur where the males are found earlier than this and I have taken specimens at Philo, Illinois, as early as July 14. The early appearance of a few males is often caused by egg-laying workers in a colony where the queen has become lost or killed.

Because of the comparative lateness of the appearance of the queens in spring, the workers are seldom found in the vicinity of Urbana, Illinois, at an early date. The earliest record that I have for a worker in this vicinity is June 24, 1911. Experiment 16, 1917, and Experiment 28, 1919, both show that the first workers were not produced in these

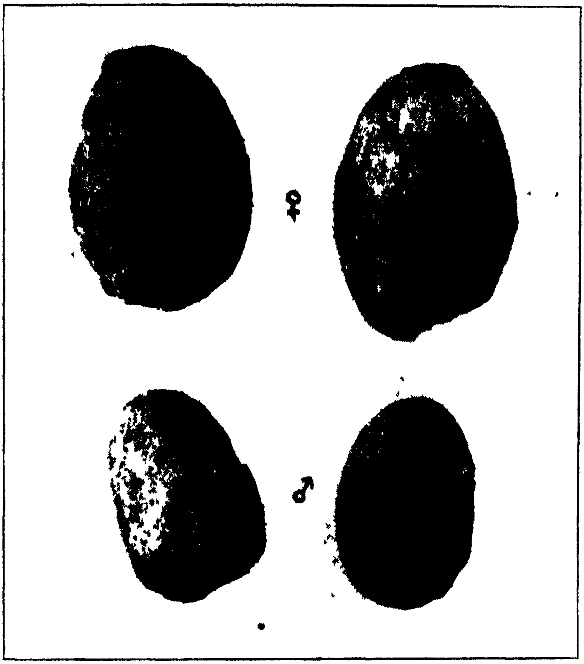


FIGURE 5. Male and queen cocoons of *Bremus americanorum*.

colonies until the last of June. After the appearance of the first workers, the number encountered in the field rapidly increases, and their maximum abundance occurs during the middle or last of August.

A large amount of data in my possession concerning the time of capture of all castes of this species in other parts of its range, confirm in general what has just been stated relating to the time of appearance of the various castes. In the southern part of the range of this species the appearance of the over-wintering queens is hastened. Accordingly, the queens in such regions are common in March. This, of course, hastens the production of the worker caste and undoubtedly has its effect upon the span of existence of the colony and the time of rearing of the sexual castes.

5. Caste Ratio.

It is fairly evident that many more workers are produced as a rule than either males or queens. In large colonies, however, the combined number of males and queens may occasionally equal the number of workers. Examination records are not sufficient to show whether more males are produced than queens, or *vice versa*, but generally in my observation boxes a larger number of males emerged than did queens.

6. Size of Colonies.

Although the size of colonies of bumblebees varies as the result of their being the victims of favorable or unfavorable circumstances beyond their control, it is also true that certain species produce under optimum conditions smaller colonies than certain other species. The colonies of *B. americanorum* average very large in comparison with other Illinois species such as *B. auricomus*, *B. bimaculatus* and *B. vagans*. This is probably best explained on the basis of the high fecundity of the queens (I have found nineteen eggs in a single cell) and the long seasonal adjustment of the species. In the following table is given a summary of the contents of some of the natural colonies found near Urbana, Illinois, from 1919 to 1927.

Summary of the Contents of Some of the Natural Colonies.

Date	Workers	Queens (Young & Old)	Males	Old Cocoons	Good Cocoons (L or P)	Eggs	Larvae	Pollen-pots
June 20.......	0	1	0	0	0	?	0	1
July 23.......	4	1	0	4	15	33	15	?
July 25.. .. .	44	1	0	78	18	49	22	12
August 4.	11	1	0	23	8	18	21	?
August 4.	17	1	0	45	32	52	?	?
August 12.....	23	0	11	36	17	7	48	16
August 28.....	7	8	7	50	29	?	5	?
September 6..	69	11	10	?	45	?	31	19
September 9..	76	57	46	?	101	28	35	16
September 14.	38	21	9	132	34	0	0	1
September 13.	98	71	25	?	236	4	?	18
September 17.	27	25	24	278	80	8	15	?
September 25.	13	16	5	192	48	?	?	?
September 26.	15	?	?	244	10	?	34	?
October 3.....	10	0	0	?	0	0	0	?

It can readily be seen from this table that the colonies of this species are most populous in late summer and early fall. One of the nests examined on September 13 contained one hundred and ninety-four adult bees, besides two hundred and fifty-six cocoons from which the adults had not as yet emerged. Almost all of these latter cocoons eventually produced either males or queens, but a few produced workers; making a known total of more than four hundred bumblebees produced in this

nest. The average number of bumblebees of this species produced in a nest, however, is commonly less than two hundred. Mention has already been made that the comb in Experiment 29, 1919, was over twelve inches in diameter and I may add that it was nearly five inches in height in some places.

7. Variation.

This species does not exhibit striking variations in the color of the pubescence of the female castes. Certain specimens, of course, show

FIGURE 6 Type of community in which the colonies of *Bremus americanorum* are most frequently found in the vicinity of Urbana, Illinois.

more yellow or black pubescence than do others, but such variations are not pronounced and as far as my records are concerned can not be associated with definite localities or geographical areas. In the case of the males, however, marked color variation is more common and the various color phases occurring have caused the making of several synonyms. The apical dorsal abdominal segments of the male may be black, yellow, ferruginous, or combinations of these colors. All these color variations may occur within the same nest as I have repeatedly observed. Cresson (1863) was the first to note the occurrence of males with black, yellow, or combinations of these two colors in the same nest,

but he thought the males involved belonged to what is now known as the genus *Psithyrus*. Franklin (1913) does not mention the occurrence of these differently colored males in the same nest, but in his description of the male of *americanorum* correctly includes the various colored forms. I have frequently found the differently colored males in the same nest, but the red-tailed forms were always the rarest One colony of this species which I studied in 1917, contained on September 12, twenty-six males. Twelve of these had black, eleven yellow and black, and three ferruginous pubescence on the apical dorsal abdominal segments.

Although variation in size exists in all castes, it is particularly pronounced in the case of the workers. The workers that are produced in the earlier part of the season are often very small, whereas those that are produced later in the season may nearly equal the queens in size. The variation in the size of the males is oftentimes considerable, but it does not compare with that found in the workers. In a recent publication (Frison, 1927b) an illustration was presented showing all three castes and the variation in size shown by the females and males. In that paper data were presented indicative of the fact "that polymorphism of the females is due to trophogeny." Apparently all the females which measure over eighteen millimeters in length, have a width of ten millimeters at the second abdominal segment and are produced in late summer or fall, hibernate and start colonies in spring. The smallest worker of this species that I have studied measured but nine millimeters in length.

8. Cocoons and Food Storage.

The first structure used by the queen in spring for the storage of food is the wax-pollen honey-pot. This is constructed a short distance from the first egg cells or incipient comb. After the first workers emerge, this honey-pot is destroyed or loses its identity because of the rapidly expanding comb. As soon as empty cocoons are available they are renovated and used for the storage of honey and when full of honey are frequently capped with a hood of wax-pollen composition. It usually happens that there are more empty cocoons than honey surplus and accordingly many cocoons are not utilized for any purpose. I have seen the cocoons of males and queens utilized for the storage of honey as well as those of the workers, showing that size has nothing to do with their selection for honey storage. Sometimes fairly large quantities of honey are found in the cocoons in late summer and early fall and this has led to the destruction of many colonies of these beneficial insects by thoughtless individuals. One nest of this species which I examined on September 17, at White Heath, Illinois, contained two hundred and seventy-eight cocoons which had produced adults and one hundred and eighty-nine of these contained honey.

Mention has already been made of the fact that this species of bumblebee makes small cup-shaped wax-pollen pockets on the sides of small groups of larvæ and hence belongs to the "Pocket-maker" section in the terminology of Sladen (1912), the *Marsipoea* of Plath (1927b) and the *Odontobombus* of Krüger (1917). The last-mentioned term was

originally applied to the bumblebees upon the basis of structural characters, but since it applies to a natural biological unit equivalent to the *Marsipoea* it may conveniently be used for both systematical and biological groupings. When these pockets are small they nearly always appeared to be empty, but twice I have seen a little pollen in them. As the larvæ grow larger these pockets disappear or are considerably enlarged and used for the storage of large quantities of pollen. When so enlarged and altered their origin is easily overlooked. Less frequently the pollen is stored directly in renovated cocoons. The pollen found in the "pockets" on the sides of groups of small and medium-sized larvæ in the case of the "Pocket-makers" is thought by Sladen (1912), Wagner (1907) and Plath (1923a) to be directly utilized by the larvæ. The location of these pockets and the storage of pollen in them is suggestive of the fact that this pollen is directly used by the larvæ as food but not conclusive. Certainly, in the case of this species, many of the medium to large-sized larvæ are fed a regurgitated liquid food directly by the bees through openings in the larval cells and this method of feeding may be resorted to earlier. The nature and quantitative distribution of this liquid food to the various castes still awaits much research. In Figure 1, one of these small pockets can be seen attached to a group of small larvæ, and also alongside of the cocoons several of the large wax-pollen pots which originated as pockets. Figure 4 shows a side view of the same nest and the large wax-pollen pots.

The largest cocoons found in nests in late summer and fall are almost certain to produce queens. The cocoons which produce males are usually larger than those which are spun by the workers in the early summer. One cocoon of a male that I measured was nearly sixteen millimeters in height and twelve millimeters at its greatest diameter. The cocoons of queens are often nearly twice the size of those of males or workers. Figure 5 is a photograph, somewhat enlarged, of queen and male cocoons of this species.

9. Mating.

Mating takes place under natural conditions with this species usually in the latter part of August or September. Robertson (1890) has recorded seeing a male and female mating on September 9, and the observations by Fairchild and Barret (1906) were made in October. I have frequently seen males try to copulate with queens in my observation boxes in the early part of September, and in several instances they were actually seen *in coitu* within the nest. In such cases the males mated with queens produced in the same nest. As recorded elsewhere, the writer (1927c) has successfully induced males and queens of this species to mate under controlled conditions.

One frequently becomes aware of the presence of nests of *americanorum* through seeing numbers of the males circling about close to the ground over the place of the nest. Oftentimes they rest on the top of the nest if it happens to be a grass-covered one on the surface of the ground. This behavior of the males is associated with mating, for they are merely waiting to mate with the young queens when they

leave the nest. Several times I have found males and queens mating while resting on the ground near the nests from which the queens evidently came.

10. Nesting Situations.

Almost any dry and protected situation affording material for covering the comb is selected by queens of this species for their nests. It is not uncommon for queens of *americanorum* to utilize bird nests for a nesting site as evidenced by the records of Howard (1918), Rau (1922) and my discovery of a colony which was located in an old woodpecker's nest seven feet above the ground. Usually, however, the abandoned nest of a mouse on or a short distance beneath the ground, and which is exposed to the warming influence of the sun, is selected by a queen as the site of her nest. As a result of this preference for exposed situations, the nests of this species are the ones most often encountered in open fields and grassy slopes in the vicinity of Urbana, Illinois (Figure 6). Subterranean nests are frequently found and, according to my experience, nests just below the surface of the ground where the soil is readily warmed by the sun are usually more populous than those on the surface of the ground.

11. Temperament.

The examination and study of many nests of this species have convinced me that *americanorum* is one of the most vicious and irritable species of bumblebee in Illinois if not in North America. That I am not alone in this judgment of *americanorum* is evident from the writings of Howard (1918), Rau (1922-1924), and Plath (1927a). Upon several occasions I have been forced to postpone my removal of their nests, by the use of an anesthetic, because of the vicious attacks of the workers. When their nest is disturbed many of the workers fly about in all directions and scout for the evil-doer. If their scouting is not successful, some of them will then alight on the ground near the nest and remain there a considerable time, ever on the alert for the reappearance of their potential enemy. If objects, such as an insect net, are left on the ground near the nest due to a hurried retreat, many of the workers will promptly settle on them; thus showing that they recognize such objects as foreign to their usual surroundings. The sting of this bee is quite painful to me and on one occasion a sting just back of the ear on a small blood vessel caused my hands and feet to swell and red blotches to appear all over my body. Fortunately, these effects disappeared within twenty-four hours.

12. Fighting.

Although fighting among the bumblebee queens in spring over nesting sites is not confined to any one species, *B. americanorum* is a species much addicted to this habit. The finding of old dead queens in the heterogeneous covering about the comb upon several occasions is mute testimony of such fighting. In one nest I found four old dead

queens in addition to the live mother queen. Whether the queen first to locate the desired site was the living queen is problematical. Under controlled conditions fighting frequently occurs if two queens of *americanorum* are placed in the same nesting box in the spring.

Another interesting feature of the invasion of nests by queens is that queens will occasionally take up their abode in the nests of other species. A most interesting example of this type of parasitism was discovered during the first of August in 1919. When I found the nest I took it to be a colony of *B. separatus* (Cresson) because a worker of this species rushed out in defense of the nest. When the nest was opened—it was a surface nest—I was much surprised to find that I was dealing with a mixed colony. The queen controlling the nest belonged to the species *B. americanorum*. Evidently she had invaded in the earlier part of the season a recently started nest of *B. separatus*. Besides the worker of *B. separatus* which I caught at first, the nest contained another worker of the same species and the empty cocoons from which each had emerged. Furthermore, in the nest débris I found the old dead queen of *B. separatus*. Here, then, was a case where a queen of *B. americanorum* had invaded the nest of *B. separatus*, killed the *separatus* queen and either reared the *separatus* brood or adopted them! A colony of bumblebees subjected to such vicissitudes probably never attains anything like normal size, as was the case in this instance. Sladen (1912) reports that twice he has found very small colonies of *B. lucorum* which were ruled by a queen of *B. terrestris*. The queen of *B. lucorum* had evidently been killed by the invading queen; in fact, Sladen found the dead queen of *lucorum*. It is interesting to note that in the cases reported by Sladen and the one I have mentioned, the more vicious species of bumblebee was the victor and also the invader. In the case of *B. terrestris* and *B. lucorum* the species are very closely related and such invasions are not as startling as with *B. americanorum* and *B. separatus* which not only belong to different subgenera but to different sections.

13. Parasites and Inquilines.

As already stated in literature (Frison, 1916 and 1926b), the nests of *americanorum* are invaded by the social parasites *Psithyrus variabilis* (Cresson) and the reader is referred to these articles for a detailed account of these interesting social parasites and how they influence the community life of their host. Among the most serious parasites of this bumblebee are *Brachycoma sarcophagina* (Townsend) which kill the larvæ and pupæ, and *Physocephala sagittaria* (Say) which kill the adults. Information concerning these species has already been published and need not be repeated (Frison, 1926). The nests afford a lodging place for a motley assortment of occasional lodgers and scatophagus associates (Frison, 1926); the most common in Illinois being the larvæ of *Fannia scalaris* Fabr., *Antherophagus ochraceus* Mels., and *Vitula edmandsii* (Packard). The latter may ruin the comb. I have taken nearly four hundred and fifty larvæ of *Fannia* in a single nest and few nests are found without them.

14. Domestication.

Plath (1923a) has attempted the semi-domestication of *americanorum* and so has the writer (1927a), but thus far no one has been able to successfully induce queens of *B. americanorum*, or its close relative *B. fervidus*, to develop colonies under controlled conditions. Of course, the nests may be successfully removed from natural locations and placed in observation boxes without greatly retarding the development of the colony. Both Plath and myself have found it easy to induce the queens to start a nest and lay eggs, but due to some peculiarity in feeding habits the larvæ have always died. Until this difficulty is over-come, the laboratory and economic exploitation of an otherwise most worthy species of bumblebee will be limited.

BIBLIOGRAPHY.

Banks, Nathan. 1902. Sleeping Habits of Certain Hymenoptera. Journ. New York Ent. Soc., Vol. X, No. 4, December, 1902, pp. 209–214.

Coville, F. V. 1890. Notes on Bumblebees. Proc. Ent. Soc. Wash., Vol. I, No. 4, May 15, pp. 197–202.

Cresson, E. T. 1863. Written Communication. Proc. Ent. Soc. Phila., Vol. II, pp. 164–166.

Fairchild, D. and Barrett, O. W. 1906. Notes on the Copulation of Bombus fervidus. Proc. Ent. Soc. Wash., Vol. VIII, Nos. 1 and 2, March–June, pp. 13–14.

Franklin, H. J. 1913. The Bombidae of the New World. Trans. Amer. Ent. Soc., Vol. XXXVIII, pp. 177–486.

Frison, T. H. 1916. Note on the Habits of Psithyrus variabilis Cresson. Bull. Brookl. Ent. Soc., Vol. XI, No. 2, April, pp. 46–47.

1926a. Experiments in Attracting Queen Bumblebees to Artificial Domiciles. Journ. Econ. Ent., Vol. 19, No. 1, February, pp. 149–155, Figs. 2–3.

1926b. Contribution to the Knowledge of the Interrelations of the Bumblebees of Illinois with their Animate Environment. Annals Ent. Soc. Amer., Vol. XIX, No. 2, June, pp. 203–235, pl. XVII.

1927a. Experiments in Rearing Colonies of Bumblebees (Bremidae) in Artificial Nests. Biol. Bull., Vol. LII, No. 1, January, pp. 51–67, figs. 1–4, Tab. 1.

1927b. The Development of the Castes of Bumblebees (Bremidae: Hym.). Ann. Ent. Soc. Amer., Vol. XX, No. 2, June, pp. 156–180, pls. IX and X.

1927c. The Fertilization and Hibernation of Queen Bumblebees under Controlled Conditions. (Bremidae: Hym.). Journ. Econ. Ent., Vol. XX, No. 3, June, pp. 522–526, Table 1.

1928. A Contribution to the Knowledge of the Life History of Bremus bimaculatus (Cresson) (Hym.). Entomologica Americana, Vol. VIII (new series), No. 4, October 27, pp. 159–223.

1929. A Contribution to the Knowledge of the Bionomics of Bremus impatiens (Cresson). Bull. Brooklyn Ent. Soc., Vol. XXIV, No. 5, December, pp. 261–285, pls. 24–26, figs. 1–7.

Goedart, J. 1685. De Insectis, in Methodum Redactus; cum Notularum Additione. London. Vol. 2, pp. 233–249.

Howard, L. O. 1918. An Unusual Bumblebees' Nest. Ent. News, Vol. XXIX, No. 3, March, pp. 114–115.

Jackson, L. O. 1920. Bumblebees of District of Columbia and Vicinity. Proc. Ent. Soc. Wash., Vol. 22, No. 7, pp. 162–168.

Kruger, E. 1917. Zur Systematik der mitteleuropäischen Hummeln (Hym.). Ent. Mittell, Band VI, Nr. 1-3, pp. 55-66.

Lutz, F. E., and Cockerell, T. D. A. 1920. Notes on the Distribution and Bibliography of North American Bees of the Families Apidae, Meliponidae, Bombidae, Euglossidae, and Anthophoridae. Bull. Amer. Mus. Nat. Hist., Vol. 42, Art. 15, pp. 491-641.

Plath, O. E. 1923. Observations on the So-called Trumpeter in Bumblebee Colonies, Psyche, Vol. XXX, No. 5, October, pp. 146-154.

1923a. Breeding Experiments with Confined Bremus Queens. Biol. Bull., Vol. XLV, No. 6, December, pp. 325-341.

1924. Miscellaneous Biological Observations on Bumblebees. Biol. Bull., Vol. XLVII, No. 2, August, pp. 65-78.

1927a. Notes on the Nesting Habits of Some of the Less Common New England Bumblebees. Psyche, Vol. XXXIV, No. 2, April, pp. 122-128.

1927b. The Natural Grouping of the Bremidae with Special Reference to Biological Characters. Biol. Bull., Vol. LII, No. 5, May, pp. 394-410, Figs. 1-6, Tables 1-2.

1927c. Notes on the Hibernation of Several North American Bumblebees. Annals Ent. Soc. Amer., Vol. XX, No. 2, June, pp. 181-192.

Putnam, F. W. 1864. Notes on the Habits of Some Species of Humble Bees. Proc. Essex Inst., Salem, Mass., Vol. 4, pp. 98-105.

Rau, P. 1922. Ecological and Behavior Notes on Missouri Insects. Trans. Acad. Sc. St. Louis, Vol. XXIV, No. 7, pp. 40-41.

1924. Notes on Captive Colonies and Homing of Bombus pennsylvanicus DeGeer. Annals Ent. Soc. Amer., Vol. XVII, No. 4, December, pp. 368-380, Pl. 1.

Robertson, Charles. 1890. Notes on Bombus. Ent. News, Vol. I, No. 3, March, pp. 39-41.

1903. Synopsis of Megachilidae and Bombinae. Trans. Amer. Ent. Soc., Vol. XXIX, April, pp. 163-178.

Skorikov, A. S. 1922. Palearctic Bumblebees: General Biology including Zoogeography. Bull. Sta. Regionale Protect. Plates Petrograd, IV, (1), pp. 1-160.

Sladen, F. W. L. 1912. The Humblebee, Macmillan & Co., London, pp. 283.

Vogt, O. 1911. Studien über das Artproblem. Teil 2. Über das Variieren der Hummeln. Sitzungsber. Gesellsch. Naturforsch. Freunde Berlin, (1), pp. 31-74.

Wagner, W. 1907. Psycho-biologische Untersuchungen an Hummeln mit Bezugnahme auf die Frage der Geselligkeit im Tierreiche. Zoologica, Band 19, Heft. 46, pp. 1-239.

THE CLIMATIC LIMITATIONS OF THE MEXICAN BEAN BEETLE.

S. Marcovitch and W. W. Stanley,
University of Tennessee, Knoxville, Tenn.

CONTENTS.

INTRODUCTION.

The phenomenal spread of the Mexican bean beetle, *Epilachna corrupta*, in the Eastern United States and its potentialities for destroying the bean crop are viewed with alarm by neighboring states now free of the beetle.

Many people believe the beetle can live almost anywhere and withstand great extremes of temperature. Metcalf and Flint state "further spread is sure to occur and in time its range will probably extend over almost the entire country." The Mexican bean beetle is still spreading into new territory, mostly in a northeasterly direction. This has been attributed by Thomas (1924) to winds, which come from the southwest. A study of the physical ecology of the beetle indicates that it has very definite requirements of moisture and temperature, the correct interpretation of which should enable us to map with some degree of accuracy the final limits of its distribution in the United States. Such a study should also enable us to determine those regions in which the insect may be expected to be of economic significance each season as well as the areas that will suffer occasionally, due to a series of favorable years.

LITERATURE.

Howard (1924) was the first to record the effect of the hot, dry period of 1921 at Birmingham, Alabama. He states, "Many thousands of pupæ gradually turned brown and died." The experimental effects of sunlight were also tested by Howard, and he states "An exposure to direct sunlight for two minutes was fatal to first instar larvæ one day old when shade temperatures registered 96° F." Since the bean beetle occurs in destructive numbers both in the arid west and the humid east, Graf (1925) concludes that the climatic factors of temperature and humidity are not important factors in limiting the distribution of this pest. In the season of 1925 a very severe drought in Tennessee almost wiped out the entire bean beetle population (Marcovitch, 1926). These observations led the author to make a study of the physical ecology of the beetle, which has been continued to date. Howard (1927) and Transeau (1927) made a study of the distribution of the bean beetle in Ohio, and they conclude that the beetle's environment corresponds to the area originally covered with the mixed mesophytic forest, such as is found in eastern and southern Ohio. In South Carolina, Eddy and McAlister observed that the hot, dry summers of 1925 and 1926 killed off great numbers of bean beetles and prevented the general establishment of the pest throughout the Piedmont section. During the heat waves of 1926 "All of the eggs, larvæ and pupæ, and some of the adults, were killed in many fields under observation." Sweetman (1929) summarizes the literature and shows that the western infestation in the United States is largely confined to areas where moisture is added to the fields through irrigation.

THE MEASURE OF DROUGHTINESS.

The Mexican bean beetle is undoubtedly affected by droughty periods, and the question arises how to measure the intensity of a drought. The simplest method is to record the amount of rainfall. This method is unreliable because of the large run-off that often takes place. The southeastern United States comprising Florida, the southern half of Alabama, Georgia, and South Carolina, with a high ratio of rainfall to evaporation is nevertheless subject to frequent droughts. The measure of precipitation in this area does not give an adequate idea of the

environment. The rainfall comes in torrential storms which dissipate their water in surface run-off. As high as 80 per cent of a 2.5 inch rainfall falling in four hours may be lost by run-off (Chilcott, 1911). Columbia, Couth Carolina, with 47.55 inches of annual rainfall may have 62 drought periods in nine years whereas Ames, Iowa, with only 30.4 inches of rainfall may have but 23 drought periods (Williams, 1911). Thus the degree of temperature and the amount of rainfall required to produce a particular value of relative humidity will differ in the northern United States as contrasted with the southern.

Kincer (1919) maps those areas showing thirty consecutive days, or more without .25 inch of rainfall in 24 hours. These records point out that the central Appalachian district including Eastern Tennesseė is least subject to droughts, which occur but one year in three. The plains sections are the most subject to droughts. Munger (1916) suggests that the intensity of a drought is most important and increases in a geometric relation to the length of the dry period. The single variable used is the length of the period without a 24-hour rainfall of .05 inch. The following formula is used viz.:

Severity of Drought = Length of Drought × ½ Length of the Drought.

Such a formula may approximate the actual conditions of the Pacific slope. East of the Rocky Mountains the summer rainfall is more abundant. The high temperatures that frequently prevail, however, also greatly lower the humidity of the air. The two factors are closely interdependent. In order to incorporate both temperature and rainfall, the following drought index appears to be a measure of the conditions during a droughty period in harmony with the climatic requirements of the bean beetle, in the eastern United States.

$$L \times \frac{L}{2} \times \left(\frac{100}{R}\right)^2$$

Where L = the total number of two or more consecutive days above 90°F. for the months of June, July, August, and September, and R = the total summer rainfall for the same months.

With this formula, the intensity of a drought is made to increase as the square of its duration, and includes both factors of temperature and precipitation. 100 is used in place of 1 in order to avoid decimals. A drought varies directly as the temperature, and inversely as the precipitation.

TABLE I.

Climatic index numbers, using the formula $L \times \frac{L}{2} \times \left(\frac{100}{R}\right)^2$ where L = the successive number of days above 90°F. and R = the summer rainfall.

Locality	$L \times \frac{L}{2}$	Summer Rainfall	$\frac{(100)}{(R)}$	$\left(\frac{100}{R}\right)^2$	Index Number
Birmingham, Ala.	164	16.5	6.0	36	5,904
Montgomery, Ala.	244	16.0	6.25	39	9,516
Centerville, Ala.	309	23.0	4.37	19.1	5,871
Yuma, Ariz.	3533	1.1	90.0	8100.	2,861,730
Little Rock, Ark.	173	15.0	6.66	44.35	7,612
Fort Smith, Ark.	160	14.58	6.85	46.92	7,504
San Francisco, Cal.	1	.5	200.	40,000	40,000
Denver, Colo.	11	6 5	15.38	237.1	2,607
Greeley, Colo.	64	5.7	17.54	306.2	19,584
Jacksonville, Fla.	96	26	3.84	14.74	1,421
Tampa, Fla.	292	32.77	3.05	9.3	2,715
Miami, Fla.	5	32.56	3.07	94.24	470
Orlando, Fla.	632	29	3.44	11.83	6,457
Atlanta, Ga.	33	16.3	6.13	37.57	1,237
Thomasville, Ga.	168	21.9	4.56	20.79	3,494
Springfield, Ill.	35	13.4	7.46	55.65	1,946
Vincennes, Ind.	205	15.5	6.45	41.60	8,528
Des Moines, Iowa	33	15.5	6.45	41.60	1,372
Lawrence, Kan.	96	17.7	5.64	31.80	3,052
Tribune, Kan.	132	8.6	11.62	134.5	16,758
Baton Rouge, La.	190	23	4.34	18.83	3,572
New Orleans, La.	211	23.09	4.33	18.74	3,945
Shreveport, La.	521	12.76	7.87	61.93	31,749
Mexico City, Mex.	1	16.7	5.98	35.76	36
Battle Creek, Mich.	19	13.4	7.46	55.65	1,056
St. Paul, Minn.	10	14.7	6.80	46.24	460
Jackson, Miss.	416	15.7	6.37	40.57	16,848
Columbia, Mo.	56	13.8	7.24	52.41	2,934
Helena, Mont.	4	4.9	20.4	416.1	1,664
Glasgow, Mont.	30	5.4	18.5	342.2	10,260
Boston, Mass.	6	13.5	7.40	54.76	328
North Platte, Nebr.	45	9.92	10.0	100	4,500
Bismark, N. D.	13	8.9	11.23	125.4	1,625
Agr. College, N. M.	862	5.3	18.86	353.4	304,286
Columbus, Ohio	18	12.7	7.87	61.93	1,114
Hamilton, Ohio	106	14.7	6.80	46.24	4,876
Oklahoma City, Okla.	500	12.6	7.93	62.88	31,400
Muskogee, Okla.	160	13.06	7.7	59.29	9,488
Portland, Ore.	10	4.9	20.40	416.1	4,160
State College, Pa.	7	15	6.66	44.3	310
Columbia, S. C.	88	17.9	5.58	31.13	2,728
Charleston, S. C.	34	17.7	5.64	31.80	1,079
Pierre, S. D.	49	9.2	10.86	116.6	5,684
Crossville, Tenn.	1	18.23	5.49	30.14	30
Knoxville, Tenn.	28	15.2	6.57	43.16	1,218
Knoxville, Tenn. (1925)	197	7.35	13.6	184.9	36,425
Nashville, Tenn.	50	15.01	6.66	44.35	2,2[illegible]7
Jackson, Tenn.	223	14.4	6.94	48.16	10,[illegible]27
Wildersville, Tenn.	164	15.0	6.66	44.35	7,265

TABLE I—Continued.

Locality	$L \times \frac{L}{2}$	Summer Rain-fall	$\frac{(100)}{(R)}$	$\left(\frac{100}{R}\right)^2$	Index Number
Trenton, Tenn.	326	13.6	7.35	54.02	17,604
Savannah, Tenn.	470	13.5	7.40	54.76	25,709
Perryville, Tenn.	342	13.5	7.40	54.76	18,810
Austin, Texas	1,512	10.6	9.43	88.92	134,416
Galveston, Texas	32	19.15	5.23	27.35	873
St. George, Utah	953	2.89	34.60	1,197	1,140,741
Moab, Utah	500	2.87	34.84	1,211	605,500
Roanoke, Va.	66	15.3	6.53	42.64	2,811
Diamond Sp., Va.	16	23.7	4 22	17.80	284
Fort Laramie, Wyo.	71·	4.9	20.4	416.1	28,536
Border, Wyo.	5	4 7	21.3	453.6	2,268

THE CLIMATE OF TENNESSEE.

Tennessee has an average precipitation of 50 inches and an average temperature of 58° F. The rainfall type that characterizes Tennessee has a winter maximum and a well marked minimum in autumn. Due to its great length, a variety of climates exist. Eastern Tennessee is mountainous and includes the Great Smoky Mountains, a region abundantly favored with moisture. The annual precipitation in these mountains reaches 60 inches or more, while the mean temperature is but 45° F. Knoxville is located in a valley between the Smoky and the Cumberland mountains with a mean temperature of 56° F. and has 49 inches of rain. Middle Tennessee has a mean temperature of 58° F. and about the same amount of rainfall. West Tennessee is more or less flat, with a mean temperature of 60° F. and 50 inches of rain, and is adapted for cotton raising.

A study of the distribution of the insect in Tennessee clearly shows that the beetle reached East Tennessee first, gradually spreading to Middle Tennessee and spread very slowly towards the western third of the State. At first the absence of the bean beetle in West Tennessee proved puzzling, but the unprecedented drought of 1925 threw much light on the natural spread of the beetle as well as its capacity for destruction. The bean crops of 1923 and 1924 in Eastern Tennessee were almost completely ruined, due to a series of favorable years for the beetle, whereas in the drought period of 1925 the insect almost disappeared. The influence of such

factors as temperature and moisture was clearly evident. Normally Eastern Tennessee is least affected by droughts during the growing seasons of June, July and August. The fact that the beetle is most consistently injurious in normal years indicates that East Tennessee possesses favorable conditions for multiplication. A drought such as occurred in 1925 is exceptional. The temperatures were greatly above normal and the rainfall amounted to 7.35 inches (see Fig. 1). The months of June, July, August and September registered 60 days above 90° F. and a drought index of 36,425, whereas normally but 23 such days occur and the index is 1218 (Table I).

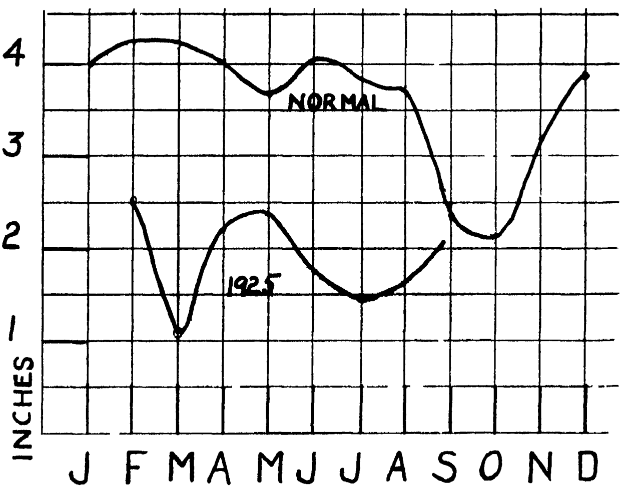


FIG. 1. Monthly precipitation at Knoxville, Tenn.

Nashville and Middle Tennessee show an index of 2217, and are somewhat less favorable for the beetle. Crossville, Tennessee, located on the Cumberland Plateau at an elevation of 1800 feet, shows a low index of 30, and suffers from beetle attacks accordingly. The years 1928 and 1929 in Knoxville were normal years, and the abundance of the bean beetle was evident.

In West Tennessee we find a somewhat lower summer rainfall than in East Tennessee and higher temperatures. Jackson averages 47 days or more above 90° F., and has an index of 10,927. When these values are plotted West Tennessee shows a curve approaching that of East Tennessee for 1925 (Fig. 2).

Although West Tennessee shows considerable uniformity, the eastern counties, such as Carroll and Henderson were the only ones to report serious damage by the bean beetle. A study of the temperature records of these counties shows that they are cooler than the adjacent counties such as Gibson and Madison. In West Tennessee, Carroll and Henderson counties are frequently referred to as "hill country." For Henderson County

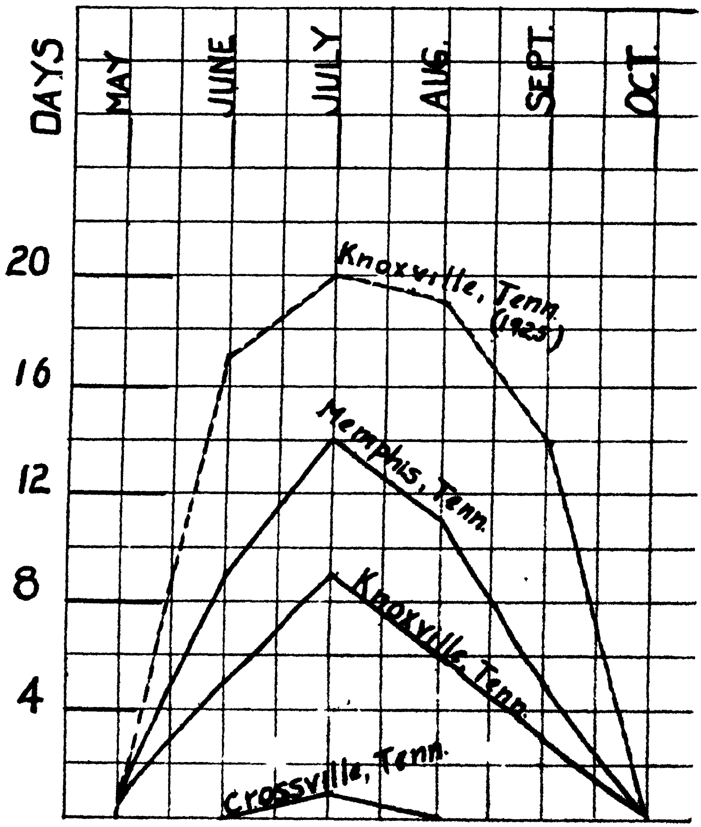


FIG. 2. Number of days above 90.

the only weather records available were for Wildersville which showed an index of 7,265. Jackson, only about 25 miles west shows an index of 10,927, while Gibson County shows an index of 17,604. West Tennessee is often spoken of as a unit, but these figures show that some towns are much hotter than others only 20 miles distant. In other words, West Tennessee,

in average years appears unfavorable for the multiplication of the beetle. In favorable years such as 1928 and 1929 with abundant summer rainfall the beetle will spread further west, and show greater capacity for destruction. During unfavorable years the beetle may actually lose territory formerly occupied as occurred in South Carolina in 1925 (Eddy, 1927).

THE HUMID EAST FAVORABLE FOR THE BEETLE.

The climates of the eastern states, especially those bordering the Atlantic Ocean, are comparatively humid, and approach the marine type of climate. As a group, they represent a combination of temperature and moisture most suitable for the life of the bean beetle. The region in the vicinity of Norfolk, Virginia, shows a drought index of only 284. Injury by the beetle is known to be severe in this section. Other localities show equally favorable conditions, such as State College, Pennsylvania, with an idex of 310.

THE LIMITING FACTORS OF THE SOUTHERN PLAINS STATES.

The southern plains states, such as Kansas and Oklahoma, have a typically continental climate, characterized by wide extremes of temperature, with a good wind movement and high rate of evaporation. The occurrence of precipitation is irregular and droughts are relatively frequent. "Hot winds" are also characteristic, with temperatures ranging from 100° to 116° F., causing great injury to growing crops and even to the bark of trees. In the western half of the state great damage is often caused in a dry season in winter from high winds blowing the loose soil of wheat fields, leaving the roots of the plant bare.

It is quite evident that western Kansas is not only too hot for the bean beetle in summer, but offers very poor hibernating quarters in winter. The drought index for Tribune, Kansas, is 16,758, while that of Lawrence, Kansas, is 3,052. Assuming that the beetle can not exist in localities with an idex over 10,000, Lawrence possesses a favorable climate, while Tribune is highly unfavorable. Oklahoma is also unsuitable for the bean beetle, since Oklahoma City has an idex of 31,400. Texas, with the exception of the higher portions of the western part, and a narrow strip along the Gulf, is much too hot for the beetle. Austin, Texas, has the high drought index of 134,116.

DROUGHT CONDITIONS IN THE GULF STATES.

Although the Gulf states are favored by abundant precipitation, drought periods are frequent because of the irregularity of the rainfall and frequency of torrential rains which dissipate in surface run-off. Montgomery, Alabama, for example, although favored with a summer rainfall of over 16 inches, is subject to hot spells in summer time with a large number of days above 90° F. Its drought index is 9,516 which represents unfavorable climatic conditions for the beetle. A glance at the map showing the present distribution of the bean beetle indicates that the beetle has not spread south of Montgomery. Birmingham, about 100 miles north of Montgomery, is more favorable for the beetle with an index of 5,904. The insect was first introduced in the vicinity of Birmingham, and with a series of favorable years produced much injury to the bean crop. However, Birmingham is subject to droughts and in average years is not especially favorable for the development of the bean beetle. Because of the lack of beetles around Birmingham, the Bureau of Entomology found it necessary to move its laboratories to Ohio, where more specimens were available for experimentation. The southern third of Alabama seems to be too hot for the beetle. Centerville, however, with an index of 5,871 and the portion along the southern border appear favorable due no doubt to the influence of the Gulf of Mexico.

It is quite possible that the bean beetle could live in southern Alabama if it was capable of crossing the hot belt south of Montgomery.

Georgia presents conditions similar to Alabama. North Georgia is mountainous and very favorable for the beetle, while southern Georgia is too hot. It is of interest to note that an isolated infestation has been present around Thomasville for several years. Thomasville, with an index of 3,494, should be capable of supporting the beetle. The fact that the beetle has not spread from Thomasville indicates that the surrounding territory is not favorable.

THE WESTERN INFESTATION OF THE BEETLE.

Colorado and the neighboring states where the bean beetle has been present for 75 years is of special interest in the study of the distribution of the beetle. Considering the phenomenal

spread of nearly 1000 miles in 10 years that took place in the eastern states, the comparatively static condition of the insect in the arid Rocky Mountains is striking. Graf (1925) believed that the beetle is adapted to the humid East and the dry West. Sweetman has shown that the western infestation is confined to the irrigated regions and that the beetle is not injurious in non-irrigated regions. Denver, Colorado, with an elevation of 5,283 feet and an index of 2,607 is fairly favorable for the bean beetle, while Greeley, Colorado, only a few miles east of Denver, but with an elevation of 4,649 shows an index of 19,584, and appears unfavorable. East of Greeley there are no mountain barriers to keep the beetle from spreading. List (1921) records the beetle from Greeley, and yet it has not spread east to any considerable extent. The eastern third of Colorado is the beginning of the hot arid plains which present an effectual barrier to the spread of the beetle eastward.

In the western states the Mexican bean beetle is known to be present in Arizona, New Mexico, Colorado, Wyoming, Texas and Utah, being confined to high elevations or irrigated regions. At present only the irrigated southeastern section of Wyoming is infested. Laramie shows an idex of 28,536 and without irrigation is not favorable. The arid conditions of the state of Wyoming appear to present an effectual barrier to the spread of the beetle into western Montana, where conditions are more favorable because of lower temperatures. West of the Rocky Mountains, the well known desert conditions offer an insurmountable barrier. While the summers are dry in the Rocky mountain states, the winters are still drier. January, 1928 at Greeley, Colorado, showed but .08 inch precipitation and maximum temperatures of 70° F. Such a combination produces an extremely dry atmosphere, which must be highly unfavorable for hibernation.

Tanner reports on the bean beetle at St. George, Washington County and Moab in Grand County, Utah. The weather records for St. George, Utah, show that this locality without irrigation is extremely unfavorable for the bean beetle, having a drought index of 1,140,741. Moab in eastern Utah is likewise unfavorable with an index of 605,500. It is likely that conditions in Utah are similar to those of Wyoming, where without irrigation the beetle could not exist. The infestation in Utah may ultimately spread along the Wasatch mountains into Idaho, western Wyoming and western Montana.

MEXICO, THE ORIGINAL HOME OF THE BEAN BEETLE.

Southern North America is believed to be the original home of the bean beetle. Since the bean beetle is a native destructive pest of Mexico at elevations above 4000 feet, a study of the climate of this country should be instructive. With the exception of the low coastal area most of Mexico is an elevated plateau ranging from 4000 to 8000 feet in height. The mean annual temperature is 60° F. and the rainfall is 30 inches,

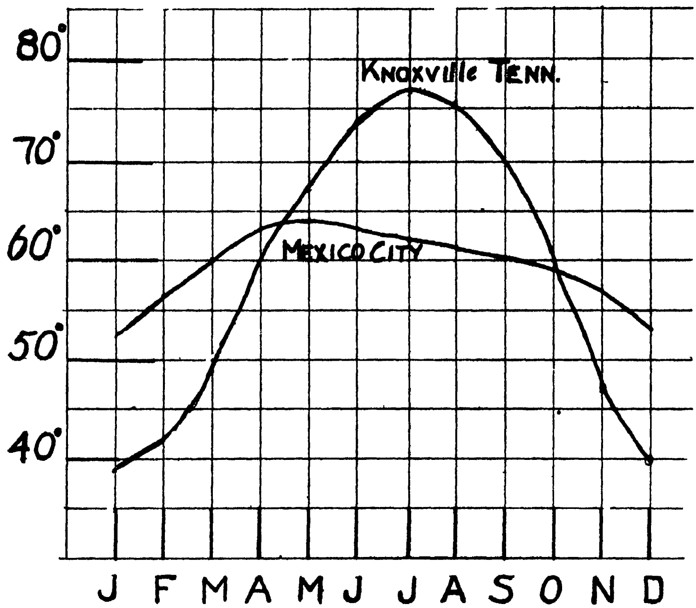


FIG. 3. Mean temperature.

most of which falls in the summer months (Fig. 3). During July and August, the months most favorable for bean growing, maximum temperatures of but 70° F. are reached in Mexico City (Hernandez, 1923). This presents a remarkable contrast considering that Mexico lies in the tropical zone. May, the hottest month in the year, has a maximum temperature of but 75° F. These comparatively low temperatures and the generous rainfall of 16 inches for the summer months, are the climatic conditions the bean beetle has been exposed to for numberless generations and undoubtedly present the optimum requirements for breeding.

Any wide departure from these combinations of temperature and rainfall may be regarded as unsuitable for the development of the insect. The drought index of Mexico City is 36. Crossville, Tennessee, on the Cumberland Plateau with an index of 30 is one of the few localities in the eastern United States that approximate the index number for Mexico. Since the Rocky Mountains extend into Mexico, there is every reason to believe that the beetle migrated from Mexico to Arizona along the elevated plateau and fed on the wild bean plants that are native to this region.

TEMPERATURE AND MOISTURE STUDIES UNDER CONTROLLED CONDITIONS.

The preceding study indicates that the beetle has definite requirements of temperature and moisture for best development, and that certain localities are more favoarable than others. There remains the gathering of experimental data under controlled conditions so as to determine the optimum temperature and moisture requirements in order to check the field observations.

STUDIES AT CONSTANT TEMPERATURES.

Methods Used in Rearing

The various stages of *E. corrupta* were reared in one-ounce tin salve boxes. The bottom of each box was covered with two or three pieces of blotting paper which were moistened each day in order to maintain the proper relative humidity.

The larvæ were secured by gathering egg masses from bean plants in the field and hatched under insectary conditions. Upon hatching the larvæ were placed in one-ounce tin boxes with moist paper and fresh bean leaves. Each day the boxes were examined and water and fresh food were added if necessary. After the larvæ entered the prepupal stage, just water was added to the boxes.

The Egg Stage

The egg stage was the only stage that was difficult to handle in this manner. If the box was too moist fungi would grow rapidly and prevent the eggs from hatching. For this reason sufficient data regarding the egg stage has not been secured to permit definite conclusions.

Incubation of eggs at various constant temperatures from limited data secured shows that both at 30° C. and at 25° C. the period of incubation was 6 days At 15° C. the eggs hatched within 14 5 days

THE LARVÆ STAGE

The growth during the larval stage was marked with the usual feeding and molting. The length of the larval stage was considered terminated when the larvæ attached themselves to the leaf

TABLE II

Length of the Different Stages of the Bean Beetle Under Constant Temperatures

Temperature	Number of Individuals	Duration in Days	Reciprocal
		Egg Stage	
15		14 5	0689
20		10 (interpolated)	1000
25		6	1666
30		6	1666
		Larval Stage	
15	23	43 66	02293
20	58	23 30	04291
25	75	16 02	06250
30	13	12 93	07751
		Prepupal Stage	
15	41	5 36	1869
20	30	3 02	3311
25	42	1 78	5617
30	20	1 60	6775
		Pupal Stage	
15	22	13 75	0727
20	86	7 39	1357
25	69	5 30	1886
30	38	4 71	2123
		Total	
15	23	77 27	01295
20	61	43 71	02288
25	69	29 10	03436
30	12	25 34	03952

Table No. II shows the average length of the different stages at constant temperatures. At temperatures ranging from 15 to 30° C. the larval stage varied from 14 5 to 49.4 days. At high temperatures such as 34° C. the young larvæ lived but

a few days. With the low temperature of 15° C. the larvæ seemed contented but required a long period of time to complete their development. Less variation in relative humidity occurred in the boxes during this stage due to the presence of food.

The Prepupal Stage

No change was noticeable during this stage of development. The length of the prepupal stage was considered from the time the larvæ fastened themselves to the leaves until the larval skin was slipped back and exposed the pupæ. The prepupal stage averaged 1 to 5 days with the low temperature showing the greatest variation.

The Pupal Stage

Considerable variation occurred in this stage which required from 4 to 16 days. This stage was not greatly affected by the variable moisture conditions.

TOTAL LENGTH OF THE IMMATURE STAGES.

The total length of time for the development from the egg to the adult stage showed considerable variation. The average time to complete development at 30° C. required but 26.8 days while at 15° C. 83 days were consumed. At 25° C. the greatest percentage reached maturity, so that this temperature may be considered as the optimum. Practically no mortality occurred at 15° C., although the period of development was greatly prolonged. At 30° C. considerable mortality occurred with but a small percentage of larvæ reaching maturity, while at 34° C. the larvæ lived only 4 days.

THE EFFECT OF LOW TEMPERATURES ON THE COLOR OF THE BEAN BEETLE.

It may be of interest to call attention to the effect of temperature on the color of the beetle. At 25° C. and above, both the larvæ and pupæ are a bright yellow color. The larvæ take on a darker hue at 20° C. due to the black-tipped spines, while the pupæ show black lines on the wing pads. At 15° C. the larvæ assume a very dark appearance because the spines including their bases become black. The rest of the larval skin remains yellow. At the low temperatures the pupæ also become dark with practically no yellow color showing. The spots on the

adults vary, although no markings were found characteristic of any one temperature. When the adults were reared at 15° C. the abdomen appeared quite dark. The dark color was not observed when the insects were reared at the higher temperatures.

MORTALITY IN A TEMPERATURE OF 100° F. AND VARIABLE HUMIDITIES.

Two temperature cabinets were regulated to keep a constant temperature of 100° F. In order to maintain a relative humidity of 80 per cent three large pans of water were placed in one cabinet and towels were hung in the water so that they formed a wick. This method gave a relative humidity of 80 per cent.

TABLE III.

Showing 50 Per Cent Mortality in Hours Produced by a Temperature of 100° F. and Variable Humidities.

	40 Per Cent R. H.	80 Per Cent R H.	100 Per Cent R. H.
Small Larvæ	6 75	8	4 83
Full Grown	13 75	22 5	12 5
Adults	10 64	25	12 5

The second cabinet was found to have a relative humidity of 40 per cent. The percentage of relative humidity was determined by using a stationary wet and dry bulb instrument manufactured by the Tycos Instrument Company.

For the production of 100 per cent relative humidity Ehrlenmeyer flasks were half filled with water and kept tightly stopped during the experiment. The insects were suspended in the space between the water and the stopper.

At 100° F. and a relative humidity of 80 per cent young larvæ lived but 8 hours, while full grown larvæ and adults lived 21 hours (Table III). Forty per cent relative humidity produced a kill in almost half the time. It is of interest to note that 100 per cent relative humidity is about as fatal as the dry atmosphere produced by 40 per cent. At 77° F. and relative humidities of 58 to 100 per cent, practically no mortality occurred, the insects living for several days.

Sweetman (1929) in his observations on the bean beetle in Wyoming considers moisture and precipitation as more important factors than temperature in the distribution of the insect.

The experimental work, however, indicates that temperature factor is the more potent in the life economy of the insect. Temperature and relative humidity are interdependent and vary inversely, high temperatures producing low humidities. The low humidities are fatal to the bean beetle only as the temperature is increased beyond the optimium of 77° F.

Above 100° F. the insects succumb rapidly. At 106° F. small larvæ lived but 7½ minutes, while at temperatures ranging from 108 to 112° F. full grown larvæ and adults lived 10–12 minutes.

A few experiments were also performed with larvæ crawling on heated soil in full sunlight. Surface temperatures ranged from 106 to 127° F. at the time shade temperatures were 90° F. When the soil temperature registered 106° F. small second instar larvæ lived 3½ minutes. At 115° F. they succumbed in one minute, while full grown larvæ lived for two to five minutes.

FUTURE SPREAD OF THE BEAN BEETLE. BASED ON CLIMATE.

In any study of the probable distribution of an insect, and its fitness to live in a new environment, a knowledge of the following aspects is important:

(1) Origin and history of the insect.
(2) Climate of the original locality of the insect.
(3) Optimum temperature and moisture requirements, determined by breeding.
(4) Conditions favoring optimum development of the host plant.
(5) Food availability.
(6) Ability to aestivate.

The first criterion is easy, for we know that the bean beetle originated on the table-lands of Mexico.

While Mexico is situated in the tropical zone, its tablelands are sufficiently elevated to have a temperate climate, and a few localities are even in the cold zone. The hottest months are characterized by maximum temperatures of 75° F. With 16 inches of rainfall during the summer months, the relative humidity is undoubtedly high.

In order to determine the most favorable temperature and moisture requirements for the development of the bean beetle, a number of the insects were reared under controlled conditions. The experimental data indicate that the largest percentage survived at constant temperatures of 77° F. and a relative humidity of 80 per cent. These figures undoubtedly represent the optimum conditions for breeding, and coincide in a striking manner with the climatic factors prevailing in the original breeding grounds of Mexico.

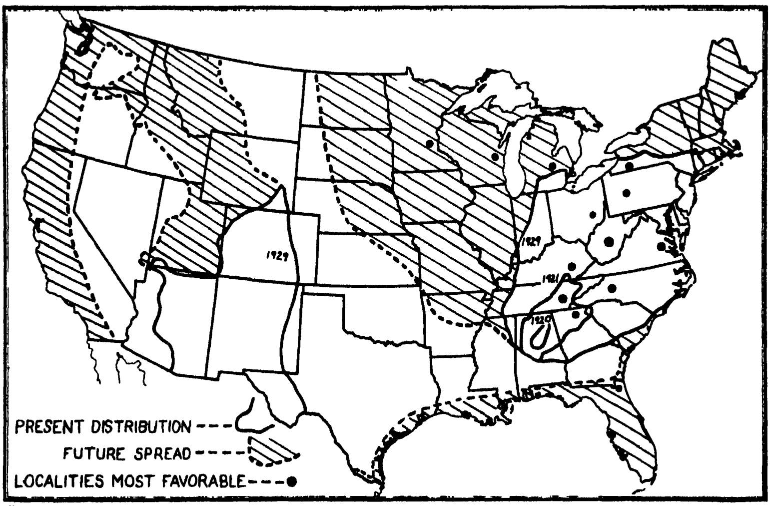


FIG. 4. Spread of the Mexican Bean Beetle.

The bean itself, the host plant of the beetle, requires cool nights, ample rainfall, and a comparatively high humidity. Cox and Pettigrove (1924) believe that these conditions are met with in eastern Michigan and account for the particular adaptation of a great part of Michigan land to bean production. In southern Michigan counties, the frequently prevailing hot weather of midsummer, which greatly favors the corn crop, prevents the suitable setting and filling of bean pods.

The conditions favoring the culture of the cultivated bean are also favorable for the breeding of the beetle, and it is safe to say that the abundance of garden beans in the East has been a factor of no small importance in the rapid spread of the beetle.

On the other hand, the inability of the bean beetle to tide over unfavorable conditions has been a handicap. Breitenbecher (1912) has shown that the potato beetle (*Leptinotarsa decemlineata*) has the power to desiccate itself when placed in an arid environment, ceases breeding and enters the ground to aestivate. With the approach of favorable temperature and moisture conditions, the beetle comes to the surface and begins breeding. In Tennessee, potato beetles are always abundant and destructive in the spring months, but are seldom noticed during the hot summer months. This accounts for the fact that we have but one full generation of potato bugs, even though there is time for four generations. The bean beetle, however, has not the power to cease breeding and the approach of hot weather is often harmful to the second or third generation. This is probably the principal reason that the potato beetle has been able to cross the hot plains and reach the Atlantic coast, while the bean beetle had to be transported to the humid east in order to reach the coast.

Knowing the climatic requirements of the bean beetle, and having determined those localities most favorable for its development, we are now in position to map the future distribution of this pest. With the aid of the formula $L \times \frac{L}{2} \times \left(\frac{100}{R}\right)^2$ as discussed previously, we can assign an index number to any locality desired. The Mexican bean beetle appears to thrive in those regions having an index of 2000 or less, and these may be considered the "normal" zone of occurrence (Cook, 1925). Regions with an index of 2000 to 6000 (See Table I) will be subject to periodic infestations, and may be considered areas of "occasional" abundance. In a series of favorable years these areas may suffer greatly from the ravages of the pest. Localities above 10,000 may be considered highly unfavorable for the development of the bean beetle.*

*Another severe drought occurred in 1930 over the Ohio valley, accompanied by a scarcity of bean beetles. Added confirmation of the conclusions reached in this paper is shown by the climatic index numbers that were reached at representative localities. Knoxville, Tennessee, for example, attained an index of 17,253. Up to September 6, 1930, the drought approached that of 1925 in severity. The last three weeks in September, 1930, cooled off sufficiently to favor the production of an hibernating generation. This did not occur in 1925. At Columbus, Ohio, the index number approached 24,000, whereas the normal is only 1,114.

After the index number of many representative localities was determined, a map showing the distribution of the Mexican bean beetle was constructed (Fig. 4). Those states that appear unusually favorable have been designated by a large black dot, and include East Tennessee, North Georgia, Kentucky, both Virginias, Pennsylvania, New York, the New England states, eastern Ohio, Michigan, Wisconsin, Minnesota, Iowa, and the northeastern part of Florida. To the north the beetle will migrate along the Great Lakes, and eventually reach Minnesota and Iowa.

In the South it will find a barrier of hot air in Central Alabama, Georgia, Mississippi, and northern Louisiana that will keep it from reaching the Gulf coast. The Atlantic coast seems to be favorable, and it is possible that the insect will travel along the eastern coast as far south as Jacksonville, and thence across to the Gulf coast and on to New Orleans Just how the bean beetle will fare in Florida remains to be seen, as much will depend on suitable hibernation quarters and availability of host plants during the summer months.

The high temperatures of central and eastern Texas, Oklahoma, and western Kansas, and the meager summer rainfall of eastern Montana and eastern Wyoming, are factors that make these regions entirely unsuitable for the breeding of the beetle.

The western infestation of the bean beetle is at present confined to the irrigated or elevated regions of western Texas, New Mexico, Arizona, Colorado, Wyoming, and Utah. The hot, dry conditions prevailing in the desert regions west of Arizona and Utah will prevent the bean beetle from reaching the western coast. On the other hand, there are good possibilities of its spreading along the mountain ranges of Utah into Idaho, and thence to western Montana, where conditions are favorable. From Montana, it will be possible for the beetle to spread into Washington, western Oregon, and the irrigated regions of California.

SUMMARY AND CONCLUSIONS.

The phenomenal spread of the Mexican bean beetle in the East has been attributed to the prevailing wind. A study of the climatic requirements of this insect indicates that there are very definite limits of temperature and moisture that favor its development and determine its potentialities as a crop pest, as well as its ability to spread into new territory

The original home of the Mexican bean beetle is the tablelands of Mexico and Central America. These elevated regions possess a uniform cool climate, with maximum temperatures of 75° F., to which the beetle is best adapted. The breeding work indicates that a temperature of 77° F. is most favorable for survival. Higher temperatures hasten development but produce greater mortality. At constant temperatures of 93° F., none of the larvæ were able to develop, while at 100° F. the small larvæ succumbed in 8 hours.

Observations during the past five years under out-door conditions show that the high temperatures prevailing in midsummer are often very unfavorable for the development of the insect. The following formula was used to measure the effects of a drought: $L \times \frac{L}{2} \times \left(\frac{100}{R}\right)^2$ where L is the successive number of days above 90° F. and R is the summer rainfall. With the aid of this formula, the climatic index number of representative localities was determined. Regions with an index number of 2000 or less appear favorable for the bean beetle. By the aid of these index numbers, a map was prepared showing the future spread of the bean beetle.

In time the beetle will reach Florida by the way of the Atlantic coast, and Minnesota by the way of the Great Lakes. The western infestation will spread along the Rocky Mountains to western Montana, and thence to the irrigated bean sections of the Pacific coast. Localities with extremely hot summers, like central Texas and Oklahoma, northern Louisiana and central Mississippi, will be exempt from bean beetle depredations. Cool humid regions, such as Eastern Tennessee, eastern Virginia, eastern Michigan, and Pennsylvania are most favorable for the beetle, and will suffer accordingly. Localities subject to droughts will often be free from the attacks of the pest except in a series of favorable years.

LITERATURE CITED.

Breitenbecher, J. K. 1918. The relation of water to the behavior of the potato beetle in a desert. Carnegie Inst. of Wash. pub. 263: 343–384.

Chilcott, E. C. 1911. Some misconceptions concerning dry farming. Yearbook, U. S. Dept. Agr., pp. 247–256.

Cook, W. C. 1925. The distribution of the alfalfa weevil (Phytonomus posticus Gyll.): A study in physical ecology. Jour. Agr. Res. 30: 479–491.

Cox, J. F., and Pettigrove, H. R. 1924. Bean growing in Michigan. Mich. Agr. Exp. Sta. Spec. Bul. 129.

Eddy, C. O., and McAlister, L. C. 1927. The Mexican bean beetle. S. C. Agr. Exp. Sta. Bul. 236.

Graf, J. E. 1925. Climate in relation to Mexican bean beetle distribution. Jour. Econ. Ent. 18: 116–121.

Hernandez, J. 1923. The temperature of Mexico. Monthly Weather Rev. Supplement No. 23.

Howard, N. F. 1924. Studies on the Mexican bean beetle in the southeast. U. S. Dept. of Agr. Dept. Bul. No. 1243.

Howard, N. F. 1927. Correlation of the Mexican bean beetle population with original forest type. Science, 65: 499–500.

Kincer, J. B. 1919. The seasonal distribution of precipitation and its frequency and intensity in the United States. Monthly Weather Rev. 47: 624–631.

List, G. M. 1921. The Mexican bean beetle. Colo. Agr. Exp. Sta. Bul. 271.

Marcovitch, S. 1926. Supplementary investigations of the fluosilicates as insecticides with observations on the effect of heat and drouth on the Mexican bean beetle. Tenn. Agr. Exp. Sta. Bul. No. 134.

Munger, T. T. 1916. Graphic method of representing and comparing drought intensities. Monthly Weather Rev. 44: 672–643.

Sweetman, H. L. 1929. Precipitation and irrigation as factors in the distribution of the Mexican bean beetle, Epilachna corrupta. Ecology 10: 228–244.

Tanner, V. M. 1929. The Mexican bean beetle in Utah. Pan-Pacific Ent. 5: 183–186.

Thomas, F. L. 1924. Life history and control of the Mexican bean beetle. Ala. Agr. Exp. Sta. Bul. No. 221.

Transeau, E. N. 1927. Vegetation types and insect devastations. Distribution of the Mexican bean beetle and European corn borer in Ohio. Ecology 8: 285–288.

Williams, M. B. 1911. Possibilities and need of supplemental irrigation in the humid region. Yearbook. U. S. Dept. Agr., pp. 309–320.

NORTH AMERICAN LEAFHOPPERS OF THE ATHYSANELLA GROUP.*
(Homoptera Cicadellidæ.)

HERBERT OSBORN.

The leafhoppers of this group have been a source of much difficulty and confusion, owing partly to the fact that the species, or most of them, show marked cases of dimorphism. All have brachypterous forms and where macropterous forms have not been found the venation is too much modified to serve as a good taxonomic character. Not only the definition of species but their generic position has been a question of great difference of opinion and a careful revision of the whole group has been a matter of necessity if the species are to be properly classified.

Material for this study has been accumulating in the author's hands for many years but it has become more and more apparent with the increase of material that some more fundamental basis than the usual external characters must be found for the limitation of the species and the determination of their affinities. This it was hoped might be secured by a study of the male genitalia, both external and internal, and it was therefore counted a happy circumstance that I was able to have the assistance of Mr. J. N. Knull in the preparation of the genital structures for microscopic study. That these furnish a really good basis for some positive conclusions will, I think, be seen from the descriptions and figures presented here. One immediate conclusion is that these structures furnish sufficient basis for the formation of at least three new genera and as these species have up to the present, not figured to any great extent in economic or general literature it is best to designate them without further delay. Moreover it is believed best to separate them from the old world genera to which they have sometimes been assigned since most of the characters on which such

* Contribution No. 104, from the Department of Zoology and Entomology, Ohio State University.

disposition has been made are superficial and probably represent convergence rather than phylogentic affinity. A glance at the synonymy of some of the species will show how wide a divergence of opinion has existed as to relative importance of different characters. Considering all these points it seems certain that it will avoid many complications of nomenclature and give better stability to re-establish the genus Athysanella of Baker to include a small group of closely related forms and to propose two or three new genera to include certain species that present very well marked differences in structure as also associated or correlated features of pretty evident nature when once the groups are defined.

While the species discussed here have very few of them received mention as economic species it is only necessary to observe the immense numbers in which they occur, especially upon the grasses of the plains region east of the Rockies and in many of the dry or semi-arid sections of southern Texas, New Mexico and Arizona to appreciate that they must act as a very heavy drain upon the forage value of the native prairie and plains grasses.

So far as observations go all the species discussed here are restricted to species of the grass family and some of them have been very definitely connected with buffalo grass and the Boutelouas but the closer restriction to particular species of grasses, if it occurs for these species of leafhoppers, has not been determined with sufficient certainty to be recorded. This may now be undertaken with the separation of the species as a basis for exact observation. For additional references and synonymy the student may consult Van Duzee's, "Catalog of Hemiptera." Types and paratypes of the new species are in National Museum, the Ohio State University, and collections of Dr. E. D. Ball, Dr. Paul Lawson, Univ. of Kans., and the author. I am indebted to Dr. E. D. Ball, for generously turning over to me an extended series of specimens including some undescribed species. To Dr. P. B. Lawson and D. M. DeLong for loan of specimens and to Mr. J. N. Knull for dissections and drawings, and Miss Charlotte King for certain drawings.

KEY TO GENERA OF THE ATHYSANELLA GROUP.

1. Males without tibial spurs 2
   Males with prominent tibial spurs 3
2. Head conic, vertex long, male genitalia small .... **Gillettiella**
   Head short, rounded or faintly angular in front, vertex broader than long, male genitalia enlarged .... **Amphipyga**
3. Male pygofer with pectinate appendage, tibial spur short, vertex wider than long, ovipositor long .... **Pectinopyga**
   Male pygofer without pectinate appendage, tibial spur usually long 4
4. Vertex usually short, wider than long, male pygofer large, usually rounded behind, without acute tooth or process at tip, species more robust, **Athysanella** Baker
   Vertex usually longer than wide, male pygofer with acute tooth or long process at tip, species usually small and slender .... **Gladionura**

Gillettiella n. g.

Head distinctly angular, subconical; vertex longer than width between eyes, flattened, margin bluntly angulate to front. Pronotum shorter than vertex; scutellum small, acuminate; elytra short, (micropterous) reaching second abdominal segment, venation faint; female ovipositor long, extending one-third beyond pygofer; male pygofer obliquely narrowed, rounded at apex, oedagus slender, basal part broad, apical part slender, curved to base, with rather thick basal process.

Type of the genus *Gillettiella labiata* Gillette.

This genus will include also *G. atropuncta* Gillette. These species differ so distinctly in genitalia from other species formerly grouped under *Aconura*, that it seems desirable to separate them as a distinct genus. They approach *Lonatura* in some characters, but considering details of elytra and head structure, it does not seem proper to refer them to that genus.

In a single macropterous specimen received from Dr. Lawson, the only one I have seen, the venation is quite different from any of the genera here given and peculiar in the apparent absence of cross nervures separating anteapical and apical cells.

Gillettiella labiata (Gill.)

(Plate IV, Fig. 20.)

Deltocephalus labiata Gillette, Colorado Exp. Sta. Bull. 43, p. 26, (1898).
Aconura labiata Van Duzee, Catalog, Hemip., p. 653, (1917).

Head slightly wider than pronotum, bluntly angular; ocelli close to margin, margin bluntly angular, front convex, one-half longer than wide; clypeus short, sides parallel. Pronotum a little more than half longer than vertex; scutellum minute; elytra minute, abbreviated, extending on to second abdominal segment.

Genitalia: Female ovipositor extended, half longer than pygofer; last ventral segment longer than preceding, hind border strongly sinuate, central part roundingly produced; male valve long, acutely angular;

plates extending slightly beyond valve, tapering to blunt apex; pygofer obliquely narrowed to rounded apex, bearing a series of delicate bristles on the submargin, a small subapical spur; style broad at base, apex sharp and outcurved; aedeagus slender rod-like, base slender, outer part thickened at base, apex tapering, slender, basal tooth oblique, (See Fig. 50, a and b).

Color: Light gray, except in variety *rufus* Gillette; vertex slightly infuscate, with pale border, central and crossline. Pronotum with faint series of spots, often obsolete; elytra concolorous; abdomen pale gray with faint dots; in male apical part of elytra with whitish veins; upper part of abdomen black with terminal segment next to pygofer white; pygofer black at base, white at tip; face whitish with fuscous arcs, apical part of clypeus and loræ fuscous; pectus and venter with white margins.

Numerous specimens from Pueblo, Garden of Gods, Ft. Collins, Colorado, (Herbert Osborn collector). Described by Gillette from Ft. Collins, Manhattan, Bellvue and Colhan, Colo. Variety *rufus?* Gillette, was taken on reddish soil in Garden of the Gods by the author.

Gillettiella atropuncta (Gill.)

(Plate IV, Fig. 21.)

Deltocephalus atropuncta Gillette, Colorado Exp. Sta., Bull. 43, p. 28, (1898).
Aconura atropuncta Van Duzee, Cat. Hemip., p. 653, 1917.

Head narrower than pronotum, sharply angular; vertex more than one-half longer than wide; ocelli close to margin, front long, faintly convex; clypeus long, sides parallel. Pronotum, short, a little more than half as long as vertex; scutellum small, acuminate. Elytra short, broadly rounded behind, reaching on to third abdominal segment. Abdomen sharply tapering, ovipositor extended.

Genitalia: Female last ventral segment sinuate; male valve long, slightly exceeded by plates which taper to nearly acute tips; pygofer obliquely narrowed, apex broadly rounded; internal genitalia slender; styles narrow, tips out-turned; aedeagus slender, basal process at right angles. (Fig. 51, a and b).

Color pattern similar to *labiata* Gillette, females with three distinct double stripes on abdomen; male with conspicuous median line and transverse bars on vertex, milky subapical band on elytra, and bluish white band on pygofer; male pygofer bare, jet black, apex dull whitish; face with distinct, transverse band including apex of front and base of clypeus and loræ white.

The species was described from La Porte and Ft. Collins, Colo., and the writer has collected it in 1910 at Brownsville and San Antonio, Texas, and Delphos, Kansas. Specimens in DeLong and Osborn collections from Clay Co., Kansas, and in the Lawson collection from Kansas and Nebraska.

Genus **Amphipyga** Osborn.

Ohio Biol. Sur., Bull. 14, p. 289, 1928.

Robust species with the vertex short, rounded or slightly angulate and usually with two conspicuous black spots or lines between the ocelli. There is no tibial spur in males and the females have long extruded ovipositors but not in most species so extremely elongate as in some of the species of *Athysanella* or *Gladionura*. The male pygofer is inflated or elongate, the valve large and the plates broad, often divergent. Type *Amphipyga balli*.

KEY TO SPECIES OF AMPHIPYGA.

1. Elytra not reticulate or with fuscous maculations 2
   Elytra with many cross veins and with fuscous maculations in cells, **reticulata** n. sp.
2. Male plates long, usually reaching nearly to tip of pygofer 3
   Male plates short, much shorter than pygofer, usually divergent. 6
3. Smaller species, 2 to 3 mm. long....................... 4
   Larger species, usually 4 to 5 mm. long..................... 5
4. Vertex faintly angulate, spots usually present; male plates broad, divergent, tapering to blunt tips; pygofer without blunt tooth at tip; color gray or whitish.................................**occidentalis** Baker
   Vertex rounded, not at all angulate, spots often obsolete; male plates contiguous, scarcely divergent, tips broad and rounded; pygofer with small blunt tooth at apex.... ....**aridella** n. sp.
5. Male pygofer very long, obliquely truncate.........................**alta** n. sp.
   Male pygofer broad, rounded behind..........................**stylata** n. sp.
6. A black dot at tip of vertex, usually distinct, sometimes obscure. Larger species, 3-4 mm.. 7
   Spots of vertex near together, black dot at apex faint or wanting; small, 2 mm. or less...**californica** n. sp.
7. Elytra with faint or narrow lines; female segment truncate or emarginate, striate; male plates longer than wide; pygofer oblique-elongate and with acute tip......................................**acuticauda** Baker
   Elytra with broad stripes; female segment bisinuate; male plates very short, wider than long; pygofer short, not acute at tip, style exposed, **balli** n. sp

Amphipyga reticulata n. sp.

Head large, wider than pronotum; vertex wider than long, rounded, faintly depressed behind the middle; front broad, tumid, convex in profile. Pronotum nearly as long as vertex, distinctly concave behind. Elytra short, roundingly truncate. Ovipositor rather short, extending about one-fifth its length beyond the pygofer; last ventral segment short, scarcely as long as preceding, truncate or somewhat emarginate.

Color: Dull gray, with distinct fuscous markings, vertex with two large black spots, and some minute dots, spots obsolete in one specimen; frontal arcs distinct, sutures black. Pronotum with six dots near the anterior border, and a dot near the hinder edge at the side. Elytra hyaline, with fuscous maculations in the reticulate cells; veins whitish. Abdomen rather strongly marked with fuscous, the spots of the median and lateral lines merging into stripes. Pygofer with distinct fuscous stripe, hind border of segment and the ovipositor, especially

tip, blackish. Pectus and disc of venter, blackish. Legs somewhat infuscate.

Length: Female, 4 mm.

Described from two females from the collection of Doctor E. D. Ball, Elsinore, Utah, April 22, 1906.

A male which probably belongs with this species lacks the black spots of the vertex and the distinct reticulation of the elytra, and the front is less tumid. The pygofer is long, sloping, apex rather acute, valve short, angulate posteriorly, the plates widely separated, divergent, triangular, apex acute and reaching apex of pygofer. Style long, tip slender. One specimen Monroe, Utah, July 25, 1906, from the collection of Doctor E. D. Ball.

Amphipyga occidentalis (Baker).

(Plate I, Fig. 2.)

Athysanella occidentalis Baker, Psyche, Vol. VIII, p. 186, 1898.
Athysanella minuta Baker, Psyche, Vol. VIII, p. 189, 1898.
Aconura occidentalis Van Duzee, Catalog, Hemipt., p. 653, 1917.

Head as wide as pronotum, faintly angulate; vertex wider than long, as long as pronotum; front broad; clypeus slightly longer than wide; loræ broad; cheeks faintly sinuate. Elytra in macropterous form slightly exceeding ovipositor, brachypterous form extending on to base of abdomen. Female ovipositor about one-third longer than pygofer, last segment short, hind border distinctly sinuate. Male pygofer elongate, obliquely truncate, apex rounded, valve large, sub-angulate, plates triangular, scarcely longer than valve, diverging, outer border slightly sinuate. Style blunt with a blunt tooth near its apex. Aedeagus slender, curved, inner margin faintly serrate. (Fig. 30, a and b).

Color: Light gray; elytral veins faintly bordered with fuscous; brachypterous form sub-hyaline, scarcely marked; abdomen with a fairly distinct series of fuscous spots, bordering the median line, and fainter series laterally.

Length: 2.5 mm.

This species was described from Colorado, and besides the type specimens seen I have material from Fort Collins, Colo., Bismark, North Dakota, and Doctor Ball's collection includes specimens from North Colorado and Denver, as well as Fort Collins. Baker's *minuta* is evidently the male of this species as only females of *occidentalis* and males of *minuta* have been noticed in all the specimens examined, and considering close agreement in all general characters, and that they are often collected together, I am satisfied that they should be merged and *occidentalis* has priority on account of position in the published paper.

Amphipyga aridella n. sp.
(Plate I, Fig. 4.)

Head wider than pronotum; vertex wider than long, as long as pronotum, front border rounded; front broad, scarcely longer than wide; clypeus wide, sides nearly parallel; pronotum short, hind border nearly straight; scutellum small, elytra extending on to second abdominal segment. Abdomen broad, contracted posteriorly; ovipositor exceeding the pygofer about one-fifth of its length; last ventral segment short, sinuate, median lobe polished. Male pygofer rather long, sloping, hind border sinuate, apex with a minute tooth; valve large rounded behind; plates broad, broadly rounded at apex, sides sinuate, reaching to tip of pygofer; style short, apical part enlarged, subcapitate; aedeagus curved, margins minutely serrate. (See Fig 31, a and b).

Color: Pale gray, somewhat tinged with fulvous, the usual round black spots of vertex often obsolete in many specimens. Elytra hyaline, veins faintly edged with fuscous: abdomen fuscous with yellow spots on the basal segments and at sides, or mostly fulvous with series of fuscous dots.

Length: Female, 2.5 mm.; male, 1.75 mm.

Described from a series of specimens collected by the author at Tucson, Arizona, Feb. 1910, (Type No. in National Museum 43177), and another collected by Dr. E. D. Ball, at Mojave, California. This is a small species about the size of *occidentalis* but with a different fulvous tinge, a more rounded vertex and very distinct genitalia.

Amphipyga alta n. sp.
(Plate V, Fig. 24.)

Large, robust, head wider than thorax; vertex wider than long, a little longer than pronotum, pronotum short, distinctly convex behind. Elytra reaching third abdominal segment, broadly rounded behind in female, more nearly truncate in male. Male tibia not spurred, female ovipositor moderately long, extending beyond the pygofer about one-fourth its length; last ventral segment long, truncate or slightly convex, minutely rugose at middle; male pygofer very long, tapering toward a broad tip which has a strong, chitinous lobe or tooth at the inferior angle; valve long, angulate behind; plates long, reaching nearly to tip of pygofer, divergent, outer margin concave, apex bluntly angular; style long, nearly straight, with a broad lobe toward the base, aedeagus very long, curved, and expanded into three leaf-like parts, the edge of each being minutely serrate, (See Fig. 47a, 47b).

Color: Dull gray, distinctly marked with fuscous; vertex with lunate spot over the ocelli, a distinct one at apex, two brownish stripes on the disc, the front with a black point at base, a series of fuscous arcs and two diverging stripes toward apex, pronotum with black dots near the anterior margin, faint longitudinal stripe near the middle,

and a dusky patch toward the sides, elytra smoky hyaline, with the veins whitish; abdomen with series of black dots, merged into stripes in the male; beneath blackish; legs pale with series of black dots, middle of female segment, the male valve, styles and aedeagus, black.

Length: Female, 4.5 mm.; male, 3 mm.

Described from a series of specimens, Gallatin County, Montana, at elevation 4800 ft., April 26, 1902, (R. Benton,) and sent to me by Prof R. A. Cooley. National Museum Type No. 43178.

A series of specimens from Pierre, S. Dak. and a specimen from Devil's Lake, N. Dak. evidently belong here, although slightly larger This is the largest species of the genus, and the enormously expanded genitalia are a strong contrast with those in the related forms.

Amphipyga stylata n sp.

(Plate II, Fig. 7.)

Robust, head broader than pronotum, vertex longer than pronotum, about as long as wide, with a distinct transverse depression behind the middle, and a small depression near the tip Pronotum short, slightly emarginate. Elytra obliquely truncate, reaching to base of third abdominal segment. Ovipositor long, extending one-fourth its length beyond the long pygofer; last ventral segment convex, margins blackish; male pygofer broadly rounded behind; valve broad, obtusely angulate; plates triangular, separated at base, divergent, not reaching tip of pygofer; styles long, slender; aedeagus moderately expanded, furrowed, margins minutely serrate, inner apex with a minute sharp tooth. (See Fig. 33).

Color: Pale gray, distinctly marked with fuscous, vertex with a black line near the ocellus, black point at tip, with fainter branches extending back upon the apical depression, and faint transverse bar between the eyes, a minute black line near the base. Front with fine fuscous arcs, blackish sutures, and shaded median stripes on the apex of front. Pronotum with three pairs of black dots near the anterior margin, and, in the male, two short black stripes each side. Elytra pale fuscous, hyaline, with opaque whitish veins. Abdomen with series of black dots each side of the middle, and black lines at the sides of the usual pattern. Beneath black except at the margins, the apex of female segment, base of male valve, and inner genitalia, black.

Length: Female, 4 mm.; male, 3 mm.

Collected at Grand Junction, Colo., by the author, March 1910. Types in National Museum (No. 43179) and author's collection.

A possible variety is noted in a male specimen with markings obscure and with the internal genitalia, (Fig. 49) somewhat different but this was taken at same date and locality and I

believe it to be only a variation. Comparison of the internal genitalia of a number of specimens may be necessary to determine this matter. As seen in undissected specimens the one shown in Fig. 33 seems to be correct.

Amphipyga acuticauda (Baker).

(Plate I, Fig. 1.)

Athysanella acuticauda Baker, Psyche V. VIII, p. 187, (1898).
Aconura acuticauda Van Duzee, Catalog, Hemip , p. 653, (1917).

Head wider than pronotum; vertex bluntly angular, two-thirds as long at middle as width between eyes. Pronotum about as long as vertex. Scutellum small in micropterous, larger in macropterous form. Elytral veins running to apex, no anteapical cells in micropterous, two and broad costal cells in macropterous form.

Female segment truncate or slightly concave; ovipositor extending a little more than one-fifth beyond pygofer; male valve large; hind border rounded; plates short, triangular, reaching a little more than half way to tip of pygofer; pygofer broad, short, somewhat produced and angular or bluntly dentate at tip, with stiff submarginal bristles above, (See Fig. 28).

Internal Genitalia: Styles elongate, simple, nearly reaching tip of plates, aedeagus strongly curved, tapering to sharp point with large basal spur.

Length: Female, 3.5-4 mm.; male, 3 mm.

Described from Illinois. I have collected specimens from Iowa, Maine, Kalispell, Mont., Brookings, S. D., Fort Collins, Colo., Devil's Lake, N. D., and it has been recorded from New York. It probably occurs throughout the range of Canadian blue grass which appears to be a favorite food plant. It often occurs in enormous numbers and must constitute a serious drain on the forage value of this grass.

Amphipyga balli Osborn

(Plate I, Fig. 3.)

Amphipyga balli Osborn, Bull. 14, Ohio Biol. Survey, 1928, p. 289.

Resembling acuticauda in size and general appearance but with distinct stripes on the elytra and very different genitalia. Head slightly wider than pronotum; vertex broad, faintly angulate, as long as pronotum; front narrowing uniformly to clypeus; clypeus broad, slightly elevated medially; loræ large; cheeks narrow. Pronotum faintly striate. Elytra reaching base of abdomen, truncate behind. Abdomen broad. Female ovipositor extruded about one-fourth its length; last ventral segment short, scarcely longer than preceding, truncate or very faintly sinuate, polished. Male, pygofer, short, lower angle slightly produced; valve broad, rounded behind; plates short, triangular, inner border sinuate; style large, with a long spur; aedeagus expanded, furrowed and serrate. (See Fig. 29).

Color: Light gray, a large round black spot each side on border between vertex and front, a small black dot at apex, three pairs of small fuscous dots on pronotum, and three broad stripes and a wedge-shaped shorter one on the elytra; the abdomen with four series of fuscous dots each side; beneath fuscous, with yellowish patches at the sides and on the middle part of the abdomen.

Length: Female, 4 mm ; male, 3 mm.

Described from numerous specimens collected at Burlington, Iowa, by the writer, Ames, Iowa, (Ball and Osborn); Columbus, Bellaire, and Marietta, Ohio, (Herbert Osborn). This species has been confused with *acuticauda*, but the details of internal genitalia as well as other distinctive characters establishes its identity. Type and paratypes in collections of author and Dr. E. D. Ball and National Museum, (No. 43180).

Amphipyga californica n sp

Small, dark colored, resembling *acuticauda* but smaller and with the veins of inner sector coalesced for some distance Head slightly wider than pronotum, vertex short, broad, slightly longer than pronotum, very obtusely angulate; Pronotum slightly concave; scutellum small; Elytra obliquely truncate, the veins of inner sector of medius coalesced with radial for nearly one-third its length; abdomen broad; pygofer large, sloping, apex rounding with a minute process at tip, and a few scattering bristles near the upper border; valve large rounded behind; plates short, approximate, wide at base, narrowing sharply to blunt, black tipped apices.

Color: Dark gray, with fuscous markings; vertex with a dark gray band and short oblique stripe at base, two shiny black spots on front border, without central dot; front with short arcs, black sutures; pronotum with two black dots near the middle anteriorly, two larger dots behind the eye, a pair of dusky stripes near the middle, and a broader patch at the side; elytra with veins whitish, bordered with fuscous, and disc of the cells obscurely hyaline; abdomen with spots united to form fairly distinct stripes, pygofer with a black spot at base; valve and tips of plates, and apical tooth of pygofer, black

Length: Male, 1.7-2 mm.

Described from a single male (holotype, author's collection) collected by the writer at Elsinore, Cal., Feb. 6, 1924. This species might be taken for a small *acuticauda*, but it differs distinctly in absence of the black dot at tip of vertex, the coalesced veins of elytra, and the shape of the plates. Dr. Ball has sent me a second specimen, from Ephriam, Utah, which agrees perfectly with the one described above except that there is a fairly distinct apical dot on vertex and a pair of dark lines on median line of front.

Pectinapyga n. g.

Vertex as long as broad, somewhat flattened, a little depressed toward the tip, rather distinctly angulate to front; ocelli distinctly above but close to the margin and very small. Pronotum short; scutellum small, wider than long, micropterous forms with elytra very short, barely reaching second abdominal segment; male hind tibia with a short spur half as long as first tarsal segment (Text Fig. 1*a*); ovipositor moderately long, extending about one-fourth its length beyond the pygofer, male pygofer with a chitnous tri-lobed or pectinate process on the lower hind border close to the apex, more or less concealed in the dry specimens, (See Fig. 48). Aedeagus with a slender basal rod, and expanded curved distal part, at the base of which is a large dorsal spur, style bilobed, acute at apex. Type species *Pectinapyga texana.*

Pectinapyga texana n. sp.

(Plate IV, Fig. 16.)

Small, rather slender, somewhat flattened. Head scarcely as wide as pronotum, distinctly angulate; vertex flattened, as long as broad, nearly twice as long at middle as next to eye; ocelli minute, close to anterior border; front slightly flattened, straight in profile, about as wide as long; clypeus half longer than width at base, sides nearly parallel, disk slightly elevated; loræ elongate, reaching nearly to border of cheek. Pronotum broad, short, about two-thirds the length of the vertex; scutellum very small; Elytra short, reaching to base of second abdominal segment; Ovipositor one-fourth longer than pygofer; last ventral segment half longer than preceding segment, hind border slightly sinuate. Male, valve short, obtusely angular; plates broad at base, elongate, more than twice as long as valve, distinctly expanded on basal fourth, inner border nearly straight, apex bluntly rounded; pygofer elongate, obliquely narrowed from base of anal tube, apex bearing a conspicuous black chitinous tridentate process, more or less concealed or enfolded in dry specimens, a small cluster of bristles near the upper hind border. Internal genitalia, style expanded, bilobed, aedeagus with slender basal rod, expanded apical part, strongly curved, with large basal process, (See Fig. 48a and b).

Color: Quite variable, pale specimens, being almost devoid of markings, darker specimens possessing fairly well marked dots, or dashes of fucous, evident between the veins of elytra and markings on abdomen; a central patch on last ventral segment of female, a basal spot on pygofer both males and females dark; on abdomen the markings consist of series of basal dots and with marginal dashes next to spiracles.

Length: Females, 3 mm.; males, 2 mm.

Described from numerous specimens from Brownsville and San Antonio, Texas.

Holotype (female) and allotype (male) Brownsville, Texas, and paratypes, Brownsville, Corpus Christi and San Antonio,

Texas, collected by the writer. Specimens also from Wellington, Kansas, collected by W. H. Larrimer, and Clay Co., Kansas (J. H. Schaffner). (Type No. in National Museum 43181).

Genus **Athysanella** Baker.

Psyche, Vol. VIII, p. 185, (1898).

Aconura Leth., Horvath, Ann. Mus. Nat. Hung. VI, p. 567, 1908.
Nephotettix, Mats., Van D., Catalog Hemip., p. 653, 1917, (in part).

The species of this genus have a superficial resemblance to species of *Euscelis*, *Lonatura*, and *Doratura*, and as restricted will include besides the type species, *magdalena*, several other forms occurring in the plains regions east of the Rocky Mountains

Head wider than pronotum; vertex somewhat produced, obtusely angulate, rounded to the front, somewhat depressed on the vertex, and usually with two large and one small black spot, both macropterous and brachypterous forms, and the hind tibiæ in the males bear a strong spine at tip usually about half as long as first tarsal segment; the male plates are variable in length and form styles strong; the pygofer truncate or rounded behind, without teeth or processes at the lower angle.

Key to Species of Athysanella.

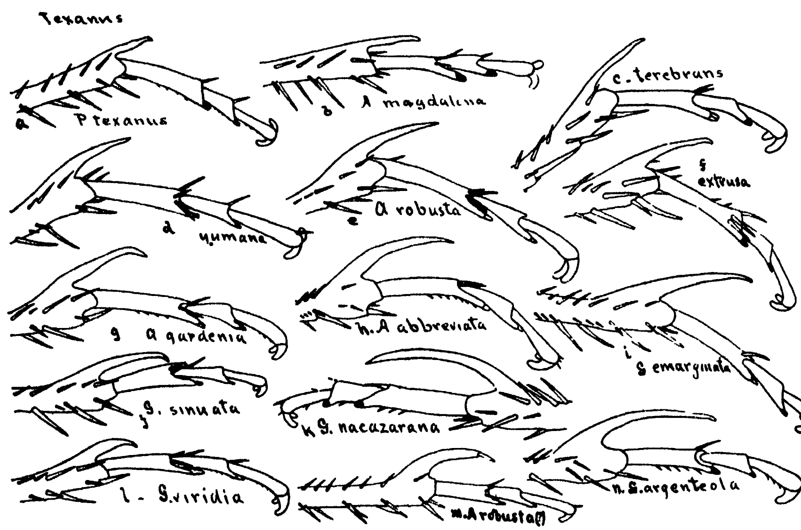
1. Vertex longer than pronotum, obtusely angulate 2
   Vertex not longer than pronotum, broadly angulate 9
2. Female segment convex or produced, long at middle 3
   Female segment emarginate or short at middle 6
3. Male plates triangular. 4
   Male plates obliquely truncate or quadrangular ....**terebrans** G. & B.
4. Male styles long capitate .... **attenuata** Baker
   Male styles slender at tip 5
5. Male pygofer rounded, plates longer than wide..........................n. sp.
   Male pygofer truncate, plates wider than long..........................**extrusa**
6. Female segment not deeply sinuate..........................**utahna** n. sp.
   Female segment deeply emarginate or sinuate 7
7. Female segment cut half way to base, male plate triangular....**yumana** n. sp.
   Female segment cut to base 8
8. Smaller, female 3 mm., male 2.25 mm..........................**gardenia** n. sp.
   Larger, female 4.5 mm, male 3 mm..........................**curtipennis** G. & B.
9. Female segment produced at middle..........................10
   Female segment emarginate or deeply sinuate at middle..........................11
10. Male plates long, female segment with long central lobe.....**magdalena** Bak.
    Male plates short, half as long as pygofer; female segment short, mid-lobe short ....**montana** n. sp.
11. Female segment emarginate half way to base, male plate short..**robusta** Bak.
    Female segment cut to near base (Tex.)..........................**excavata** n. sp.

Athysanella robusta Baker.

(Plate V, Fig. 22.)

Athysanella robusta Baker, Psyche, Vol. VIII, p. 189, 1898.
Aconura robusta. Van Duzee, Catalog. Hemip., p. 653, 1917.
Aconura robusta, Lawson, Kansas Sci. Bull., XII. p. 164, 1920.

Head large, wider than pronotum; vertex short, scarcely longer than pronotum. Pronotum slightly concave; elytra truncate; male tibial spur short (Text Fig. 1*e* and m?); abdomen tapering; ovipositor extending about one-fourth its length, beyond the pygofer; last ventral segment long, deeply excavated, median lobe about half as long as lateral; male pygofer rounded, sub-angulate on posterior border; valve distinctly angular; plates short, about half as long as pygofer, divergent, hind border rounded; styles elongate, with two long widely separated spurs, curved at the tips; aedeagus narrow, sharply angled.



TEXT FIG. I. Tibial Spurs.
a, texanus; *b*, magdalena; *c*, terebrans; *d*, yumana; *e*, robusta; *f*, extrusa; *g*, gardenia; *h*, abbreviata; *i*, emarginata; *j*, sinuata; *k*, nacazarana; *l*, viridia; *m*, A. robusta var. (?); *n*, argenteola.

Color: Pale, gray, vertex with two shiny black spots near the eyes, and brown spots at apex and on the disc, frontal arcs distinct, sutures blackish, pronotum with three pairs of black dots near the front border; elytra hyaline, cells somewhat infuscate, veins whitish; abdominal dots merging into stripes, a fuscous stripe on the side of the pygofer of the female; tip of ovipositor, brown.
Length: Female, 3.75 mm.; male, 3 mm.

Redescribed from male and female specimens, collected at Ames, Iowa. The species was described from Colorado and

has been reported from Kansas, and I have specimens from various points in Colorado, and the DeLong collection includes one from Carns, Nebraska, collected by W. D. Pierce.

Athysanella montana n. sp.

(Plate V, Fig. 23.)

Head broad, scarcely as wide as prontum, vertex wider than long, as long as pronotum, sub-angulate, front convex. Pronotum slightly concave. Elytra hyaline, macropterous female with venation of typical form with an accessory cell on each elytrom, but in different positions, and three or four cross veins at base of outer anteapical. Ovipositor about one-fifth longer than pygofer; last ventral segment short, broadly sinuate, middle lobe longest, polished black. Male pygofer short, but with a curved upturned extension posteriorly; valve rather narrow, long, obtusely angulate; plates short, half as long as extended pygofer, apex upturned, acute; styles short, tips exposed behind plates.

Color: Dull gray, with fuscous marking; vertex with a series of basal spots, a small black dot at apex; frontal arcs broken into dots, a double stripe near the apex; pronotum with a pair of dots near the middle in front, a series of fuscous patches across the disc, a central spot and triangles at base; the macropterous form with narrow fuscous edgings on the whitish veins. Male elytra unmarked; abdomen with the usual series of dots; beneath, pectus and venter on disc, blackish; legs pale with fuscous lines.

Length: Female, 3.5 mm.; male, 2 5 mm.

Described from one female, macropterous (National Museum No. 43182), one male, brachypterous, collected at Havre, Mont. by W. H. Larrimer. This species differs decidedly from *robusta* in the extended upturned tip of pygofer as well as in other details.

Athysanella magdalena Baker.

(Plate III, Fig. 11.)

Athysanella magdalena, Baker Psyche, Vol. 8, p. 185, 1898.
Aconura magdalena Van Duzee, Catalog Hemip., p. 653, 1917.

Rather small, head wider than pronotum, angulate; vertex about as long as width between eyes, convex, somewhat depressed posteriorly, roundingly angulate to front; front thick, slightly flattened. Pronotum as long as vertex; scutellum rather large; Elytra macropterous with two anteapical areoles, three oblique veins in costal areole, next the outer anteapical. Male tibial spur short, straight, (Text Fig. 1*b*).

Genitalia: Female ovipositor extended about one-third its length beyond pygofer; last ventral segment deeply sinuate, central lobe produced and bordered with black; male, valve short, rounded behind; plates elongate, divergent, inner border strongly curved, outer border nearly straight; pygofer of hind border truncate, excavated dorsally about one-half its length; internal genitalia; styles divergent, acutely pointed.

The type specimens of *Athysanella magdalena* were from Magdalena Mts., N. Mex., and Ft. Collins, Colo. Specimens collected by the writer at Pueblo, Colo., 1910, agree with type material and Baker's description.

Athysanella attenuata Baker.

(Plate II, Fig. 5.)

Athysanella attenuata Baker, Psyche, Vol. 8, pp. 188.
Aconura attenuata Van Duzee, Catalog, Hemiptera, p. 653, 1917.

Head wider than pronotum, obtusely angular; vertex about as long as width between the eyes, rounded to front, depressed to behind the middle, and with a small depressed area near the tip; front narrowed below; clypeus longer than width, tapering slightly to truncate apex. Pronotum about two-thirds as long as vertex; scutellum wider than long. Elytra, brachypterous form, truncate behind, reaching on to second abdominal segment.

Genitalia: Female last ventral segment long, nearly twice as long as preceding, produced at middle. Male valve obtusely angular; plates short, broad, obliquely truncate behind, not reaching tip of pygofer; pygofer broad, obliquely rounded behind; styles reaching tip of plates, strongly bidentate; aedeagus large, expanded toward tip, with a strong ventral furrow.

Color: Light gray; vertex and pronotum with small brown or fuscous dots; elytra with dark stripes between the veins; abdomen dotted and lined with fuscous, a quite definite line below the spiracles; disk of last ventral segment in the female and valve of male, fuscous.

Length: Female, 3.5 to 4 mm.; male, 3 mm.

Described from Colorado. Numerous specimens collected by the writer at Pueblo, Colorado, April, 1910.

Athysanella gardenia n. sp.

(Plate II, Fig. 10.)

Robust, rather short, head scarcely wider than pronotum, vertex wider than long, longer than pronotum, sub-angulate. Pronotum slightly sinuate. Elytra obliquely truncate. Male tibial spur curved at tip, (Text Fig. 1*g*). Ovipositor rather short, extending about one-fifth its length beyond the pygofer; last ventral segment very deeply excavate, lateral lobes and tip of median lobe only, showing. Male pygofer broad, hind border sinuate; valve long, narrow, sharply angular; plates broad, widely separate, quadrate, about half as long as pygofer; styles exposed, widened at the middle, extended into divergent curved tips; aedeagus abruptly curved, furrowed, margins faintly serrate (Fig. 42, a and b).

Color: Ashy gray; vertex with two conspicuous blackish spots between ocelli, a small round black spot at tip, with a minute dot each side, a faint fuscous triangle near the tip, a fuscous patch on the disc,

and a black dot near the base. The front with diminishing fuscous arcs, a double wedge-shaped spot toward the apex; pronotum with six dots near the margin; elytra ashy sub-hyaline, veins paler; abdomen with usual series of dots, apex of sixth segment black, disc of venter dusky, base of valve, style and aedeagus black; tip of ovipositor, reddish brown.

Length: Female, 3 mm ; male, 2.25 mm.

Described from a series of specimens collected by the author in the Garden of the Gods, Colorado, April, 1910. These are similar in size to *occidentalis* but differ in genitalia, and the males have a distinct tibial spur. National Museum Type No. 43183.

Athysanella curtipennis (G. & B.)

Athysanus curtipennis Gillette and Baker, Hemip. Colo., p. 92.
Nephotettix curtipennis, Van Duzee, Catalog Hemip., p. 653, 1895.

Varied with fuscous and light yellow; vertex with two prominent black spots, the elytra with fuscous stripes; abdomen rather strongly marked with fuscous; Head broader than prothorax; vertex bluntly rounded, a little more than one-half as long at middle as width between the eyes, one-fourth longer at middle than next the eye, rounded to front; front broad, narrowed uniformly to apex; clypeus, narrow toward tip, longer than width; loræ broad, not touching margin of cheek; margins of cheek slightly sinuate; pronotum short, scarcely as long as vertex; scutellum small, triangular; elytra short, extending to second abdominal segment; ovipositor long, extending one-third its length beyond tip of pygofer; last ventral segment, female, deeply excavate, lateral angles extended; male, valve large, rounded behind; plates broad, obliquely truncate at tip, outer angle rounded; pygofer elongate at lower margin, extended into slender curved spine; styles elongate and distinctly hooked at tip with a broad spur near the base. Aedeagus upturned, broad and furrowed, outer margins minutely dentate.

Color: Dull gray, the vertex with rounded black spots and triangular brown patches near occiput; pronotum with about six black dots behind the anterior margin; the elytra with six or seven fuscous stripes in the areoles; abdomen with a double median stripe, a lateral stripe interrupted by spots midway to pleura, and a pleural series of triangular spots. Face, light yellowish, the front with broken fuscous or brownish bars; beneath light yellowish with series of brownish spots on the abdomen and lateral stripes on the pygofer.

Length: Female, 4.5 mm.; male, 3 mm.

Redescribed from Colorado specimens. Numerous specimens referred here have been examined from various sources including records for "Colo"., "La Salle, Col." "Dutch Gap," etc.

Athysanella terebrans (G. & B.)

(Plate II, Fig. 6.)

Eutettix terebrans Gillette and Baker, Hemip. Colo., p. 102.
Athysanella incongrua Baker, Psyche, Vol. VIII, p. 188, (1898).
Aconura incongrua Van Duzee, Catalog, Hemip., p. 653, (1917).
Nephotettix terebrans, Van Duzee, Catalog. Hemip., p. 653, (1917).

Large, robust, head wider than pronotum, vertex longer than pronotum, wider than long, scarcely depressed on the disc, very obtusely angulate; pronotum short. Elytra nearly truncate, reaching base of third segment. Tibial spur of male slender, (Text Fig. 1*c*). Female, ovipositor long, reaching one-third its length beyond the pygofer; last ventral segment sinuate; middle lobe nearly as long as lateral, black margined; Male pygofer rounded, broad; valve long, distinctly angled; plates broad, divergent, truncate at apex; styles very large with a sharp lateral tooth; aedeagus much inflated, furrowed behind, the margins minutely serrate, apex recurved and sharp, (See Fig. 34).

Color: Pale gray; vertex with a prominent black lunate spot over ocelli, a small round black point at apex, faint brownish spots and a transverse broken bar, two minute dots at hind border; front with short fuscous arcs, an expanded double stripe on the middle; pronotum with three pairs of black dots; elytra ashy, sub-hyaline, veins a little lighter; claval suture black; abdomen with the usual arrangement of black dots, merging somewhat more into lines, disc of venter dark, and base of male valve, the styles and aedeagus, black.

Length: Female, 5 mm.; male, 3 mm.

Redescribed from specimens collected by the author at Pueblo, Colo., April, 1910. The males agree closely with the type specimen of *incongrua* in the National Museum, and females associated with them answer exactly to the description of *terebrans*. The much enlarged style and aedeagus are easily seen without dissection as they extend beyond the pygofer.

Athysanella extrusa n. sp.

(Plate II, Fig. 8.)

Similar to *curtipennis*, large, robust, head wider than pronotum, vertex a little longer than pronotum, pronotum slightly concave, elytra extending on to second abdominal segment, hyaline. Male tibia with short spur, (Text Fig. 1*f*). Female ovipositor long, extending about one-third its length beyond the pygofer, female segment very long, truncate, and longitudinally striate; male pygofer broad, truncate behind; valve very broad, obtusely angulate; plates very short, wide apart, divergent, outer margin sinuate; styles with a very long slender appendage, entirely exposed beyond the short plates; aedeagus widening toward tip, coarsely serrate at apex and with a short sharp tooth at inner tip, (See Fig. 35a and b).

Color: Dull gray or ashy, vertex with two large black spots between ocelli, and a black spot at tip extending down to the front, which has a series of conspicuous fuscous arcs. Sutures black; pronotum with faint clusters of dots, more marked in the male. Elytra hyaline, abdomen with a series of dots in the female, which merge into black stripes on the male, the median and intermediate ones including white dots. Disc of venter, middle of female segment, most of the male valve, style, and aedeagus, black.

Length: Female, 5 mm.; male, 3 mm.

Described from a series of thirteen specimens, five females and eight males, type and paratypes, from Springer, N. M., collected by C. M. Ainslee. National Museum Type No. 43184. This agrees in many respects with *curtipennis* but the female segment and male genitalia both appear very distinct.

Athysanella yumana n. sp.

(Plate II, Fig. 9.)

Robust, head broader than pronotum; vertex wider than long, distinctly longer than pronotum. Pronotum short, angularly emarginate behind; scutellum minute. Elytra reaching on to second abdominal segment, slightly convex on hind border. Male with a short tibial spur, (Text Fig. 1*d*). Female, ovipositor long, extending one-third its length beyond the pygofer, last ventral segment broadly excavate, the median lobe little more than half as long as the lateral lobes. Pygofer sparsely bristled. Male, pygofer rounded behind; plates elongate triangular, divergent, apex bluntly rounded; valve short, styles broadly bifid, the outer lobe slightly curved; aedeagus expanding dorsally, minutely serrate on hind border, tip slightly notched.

Color: Pale gray, or ashy, vertex with a black point at tip, and one over each ocellus, a faint sutural line on the elytra, the abdominal series of black points, those near the middle and at margin more distinct. A few median spots on the venter, the middle of the female segment, base of male valve, blackish.

Length: Female, 4 mm.; male, 2.75 mm.

Described from numerous specimens collected by the author at Yuma, Arizona, February, 1910. This species resembles *curtipennis* but the genital structures of both sexes differ in important details. Types in author's collection and National Museum. (Type No. 43185.)

Athysanella excavata n. sp.

(Plate V, Fig. 25.)

Robust, head slightly wider than pronotum, vertex short, wider than long, scarcely longer than pronotum. Elytra extending on to second abdominal segment. Ovipositor long, extending one-third its

length beyond the pygofer; last segment deeply excavate, leaving a triangular lateral lobe and barely showing a central lobe at base.

Color: Dull gray, markings indistinct, a faint cloud on the vertex; elytra hyaline, veins obscure; abdomen with minute dots in a series at base of segments; ovipositor tipped with brown; venter dark on the disc.

Length: Female, 4.5 mm.

Described from four specimens, two collected at Brownsville, Texas, one at Corpus Christi, and one at San Antonio, Texas, by the writer. National Museum Type No. 43186. These resemble *curtipennis* in the female segment but have no trace of the black spots and can hardly be referred to that species with certainty.

Athysanella utahna n. sp.
(Plate III, Fig. 12.)

Pale gray, or distinctly yellowish, variable with, in some cases very faint traces of dots; length, female 4.5 mm.; male, 2.5 mm.

Head, scarcely wider than pronotum, vertex long, slightly depressed behind, the middle obtusely angulate, twice as long at middle as next the eye, rounded to front; front broad, narrowing abruptly to clypeus; clypeus narrowing to tip; loræ rather narrow and short; margins of cheek faintly sinuate under the eye, otherwise nearly straight; margin, pronotum short, about three-fourths as long as vertex; hind margin sinuate; scutellum small, elytra obliquely truncate, transparent, the veins very indistinct, faintly punctured; tibial spur over half as long as first tarsal segment; ovipositor nearly one-half longer than pygofer; last ventral segment rather long, truncate or very slightly emarginate, lateral angles nearly acute; male, valve broad, hind border rounded or slightly produced medially; plates broad at base, narrowing toward the tip, divergent, outer margin concave, pygofer broad, short, hind margin rounded; styles, divergent, sharply curved toward tips, aedeagus broad, furrowed, faintly dentate, with a strong dorsal tooth. (Fig. 41, a and b).

Color: Varying from pale gray to rather bright greenish-yellow; in the male there are fairly distinct frontal arcs, otherwise markings are very faint or absent.

Described from a series of specimens from Dr. E. D. Ball, collected at Richfield, Utah, Aug. 24, Sept. 3, 1915, Sept. 6, 1915, Ephriam, July 20, Monroe, July 25, 1906, also Wray, Col., July 13, 1899, Grand Junc. Colo. July 27, 1900, Aug. 7, 1906. Types in collections of E. D. Ball, the author, and U. S. National Museum. (Type No. 43187).

Genus **Gladionura** n. g.

Slender, vertex usually longer than wide, distinctly angular, female ovipositor long, the male pygofer oblique and terminating in an acute tip, recurved hook or long process more or less curved at tip. Plates long often exceeding the pygofer, styles blunt or with blunt process, aedeagus upturned not or scarcely furrowed on the hind border but with a distinct emargination on inner part of apex. (See Fig. 44-46). Males with a long spine at tip of tibia often as long as first tarsal joint. Type species *argenteola*, Uhl.

Key to the Species of Gladionura.

1. Male pygofer short, sloping, ending in acute tip or blunt spur.............. 2
   Male pygofer narrowing and extended into a long process often curved and hooked at tip.. 6
2. Male pygofer with a blunt upturned recurved spur at tip......**recurvata** n. sp.
   Male pygofer with acute tip or short apical spur.......................... 3
3. Female segment not emarginate, convex and sinuate, male pygofer with blunt spur...**sinuata** n. sp.
   Female segment emarginate on hind border, male pygofer acute............ 4
4. Female ovipositor short, scarcely exceeding pygofer..........**abbreviata** n. sp.
   Female ovipositor considerably longer than pygofer........................ 5
5. Male plates long, not or slightly divergent, 4 mm...........**emarginata** n. sp.
   Male plates short, divergent. Small, 2-3 mm.................**frigida** n. sp.
6. Vertex long, rather sharply angular, female segment emarginate, **argenteola** Uhl.
   Vertex shorter, bluntly angled... 7
7. Larger, 4 mm., Grass green....................................**viridia** n. sp.
   Smaller, pale gray or whitish.. 8
8. Male pygofer with very long slender extension ....**extensa** n. sp.
   Male pygofer with produced sharp tip not elongate..........**nacazarana** n. sp.

Gladionura recurvata n. sp.

(Plate IV, Fig. 17.)

Similar to *argenteola*, but with produced female segment, short male pygofer, and slender style. Head slightly wider than pronotum, vertex as long as broad, nearly half longer than pronotum, distinctly depressed behind the middle, and with a shallow depression near the apex. Pronotum sinuate, elytra extending to base of third segment. Tibiæ of the male with a short spine. Female (?) ovipositor long, extending more than one-third its length beyond the pygofer; last ventral segment produced medially, lateral angles scarcely visible; male pygofer long, tapering to near tip, apex strongly bent, recurved; valve long, angulate; plates broad, outer margins sinuate; style with a rather thick elongate process directed backward, aedeagus broad, inner tip emarginate, (Fig. 38).

Color: Pale gray, markings very faint, elytra milky hyaline, disc of venter dusky.

Described from one specimen, male, (holotype) collected at Yuma, Arizona, by the writer, Feb. 1910. The female associated

with this specimen with some doubt has the segment as described, and the markings of the vertex somewhat more distinct. It is possible that it belongs to a different species.

Gladionura aridicola n. sp.
(Plate IV, Fig. 18.)

Head as wide as pronotum, angulate; vertex scarcely as long as width between eyes, longer than pronotum; pronotum short, slightly concave behind; elytra, micropterous form, short, reaching second abdominal segment, truncate. Female last ventral segment nearly twice as long as preceding, truncate; ovipositor short scarcely one-fourth longer than pygofer. Male valve obtusely angular; plates broad outer margin sinuate; pygofer obliquely truncate, with a cluster of spines dorsally; style with sharp dorsal tooth; aedagus curved, outer border sinuate, faintly serrate. (Fig. 39.)

Color: Ashy gray with dots of fuscous in series on base of abdominal segments and a dark band at base of pygofer and a central dark patch on female segment.

Length: Female, 3.5 mm.; male, 2.5 mm.

Described from one female (holotype) Yuma, Ariz. (H. O.) one female (paratype) Tucson, Ariz. and two males (allotype and paratype) Yuma, Ariz. The males placed here cannot be connected with the females with absolute certainty but agree so closely that it seems best to associate them.

In the key this would fall near *recurvata*.

Gladionura sinuata n. sp.
(Plate III, Fig. 13.)

Small, size of *argenteola*, slender, head wider than pronotum, vertex a little longer than wide, more than half longer than pronotum, faintly depressed. Elytra extending half way on second segment. Female ovipositor more than one-third longer than pygofer; last ventral segment produced, nearly twice as long as preceding, hind border sinuate, the middle lobe longest; male pygofer short, with a blunt spur at the hind angle; valve sub-angulate; plates large, extending beyond the pygofer, apex acute; style broad toward the tip, slightly emarginate on outer margin, aedeagus broad, tip rather slender, deeply emarginate on inner border, (Fig. 43).

Color: Dull gray, with very faint marks, ocelli blackish elytra hyaline; abdomen with minute dots in basal series, disc of venter blackish; female segment bordered with black.

Length: Female, 3.5 mm.; male, 2.5 mm.

Described from a long series, collected by the writer in the Garden of the Gods, Colo., April, 1910.

Gladionura abbreviata n. sp.

(Plate V, Fig. 27.)

Head wide, wider than pronotum, vertex broad, somewhat depressed, longer than pronotum, bluntly angulate to front. Pronotum rather deeply concave; scutellum minute, Elytra truncate. Female ovipositor short, barely passing the pygofer, last ventral segment emarginate, hind border sinuate; male pygofer short, apex acute, not produced; valve short, angulate; plates long, tips acuminate, extending beyond the tip of pygofer; styles shorter than plates, ending abruptly in a flattened knob; aedeagus short nearly straight, not inflated, the tip emarginate on the inner face, (Fig 45) Tibiæ of male with a long spur curved at base and a little upturned at tip, (Text Fig. 1*h*).

Color: Pale gray, some of the specimens suffused with greenish, vertex with markings obsolete, or faintly indicated; frontal arcs very faint; elytra hyaline, veins very indistinct, in one specimen a row of dots on the hind border; abdomen with minute dots; beneath, pectus and venter blackish.

Length: Female, 3 25 mm ; male, 3 mm.

Described from four specimens, one female (type) and three males (allotype and paratypes), Capa, S. Dak., Aug. 12, 1922, H. C. Severin. (U. S. National Museum Type No. 43188.) This species is unusual in the group on account of the very short ovipositor, possibly an abnormal case as only one specimen was in hand. The male genitalia, however, are quite distinct from those of any other species, although falling in the *argenteola* group.

Gladionura emarginata n. sp.

(Plate IV, Fig. 19.)

Resembling *argenteola* but larger, the female segment obliquely excavate, male pygofer shorter. Head wider than pronotum; vertex as long as broad, nearly half longer than pronotum, distinctly angulate. Pronotum short, distinctly concave. Elytra, (brachypterous) reaching second abdominal segment, macropterous female, reaching to tip of pygofer. Male tibial spur thick at base, long, (Text Fig. *i*). Female ovipositor long, extending one-third its length beyond the pygofer; last ventral segment deeply emarginate, the lateral angles incurved, the hind border sinuate, scarcely visible beyond the preceding segment, except at center where there is a short lobe. Male, pygofer sloping, rather short, the apex bluntly toothed; the valve short, slightly angulate; plates very broad, extending up onto the pygofer, tip acute, meeting on the inner border near the tip; style very broad, with two prominent lobes, reaching about to tip of plate. Aedeagus broad, with a broad emargination on inner tip, (Fig. 37).

Color: Dull gray or ashy, the markings very faint, nearly obsolete

on vertex and pronotum; elytra sub-hyaline; the veins narrowly milky; abdomen with usual dots merging into stripes in the male.

Length: Female, 4.5 mm.; male, 3 mm.

Described from a number of specimens (type and paratypes) collected at Corpus Christi and San Antonio, Texas, by the writer, Feb. 1910. National Museum Type No. 43189. Quite a number of specimens, particularly those from San Antonio, are long winged for the females and show a typical venation. Fresh specimens have a brilliant metallic green-gold color which disappears soon after they are killed.

Gladionura frigida n. sp.

Light gray, faintly marked, tinged with brownish; length female, 3 mm.; male, 2.25 mm.

Head wider than pronotum; the vertex sub-angulate, depressed behind the middle, one-third longer at middle than next the eye; front broad; clypeus distinctly narrowing toward tip; loræ elongate, cheeks slightly sinuate; pronotum, strongly arched, scarcely as long as vertex, distinctly concave behind; scutellum short, wider than long; elytra obliquely truncate, reaching apex of the second abdominal segment; ovipositor about one-fourth longer than pygofer; female, last ventral segment, broadly excavated behind; lateral angles rounded; male pygofer short, produced below but not spined; valve short, produced at center to a sharp angle; plates broad, short, divergent; claspers broad with a strong outer spur, aedeagus strongly upturned and polished, expanding dorsally.

Color: Pale gray, somewhat tinged with brown; vertex and pronotum with faint, minute brownish dots; abdomen with a series of dots at base of each segment; the front with distinct brownish or fuscous arcs. Five specimens, 3 female and 2 male.

N. Colo. 5-18, and 4-2 '98. Holotype, allotype and paratypes. Collection of E. D. Ball. (Paratypes in Osborn Collection and National Museum, No. 43190.)

Gladionura argenteola (Uhler).

(Plate III, Fig. 14.)

Deltocephalus argenteolus Uhler, Bull. U. S. Geol. & Geog. Surv. III, p. 473, 1877.
Aconura argenteola, Van Duzee, Catalog Hemipt., 653, 1917.

Small, slender, head as wide as pronotum, produced angular, but rounded at tip, vertex slightly depressed on the disc, as long as wide, longer than pronotum; scutellum minute; elytra reaching to hind border of second abdominal segment. Tibia of male with a strong, curved spine. (Text Fig. 1*n*). Female segment broadly emarginate; hind border within the lateral lobes, straight or slightly convex, narrow, scarcely as long as preceding segment. Male, pygofer sloping, pro-

duced into a sharp spine slightly curved at tip; plates broad, divergent, slightly sinuate on the margin with acute angle at tip; style blunt, as long as plate; aedeagus rather long, slender, emarginate at inner part of tip, (Fig. 36).

Light gray, or sometimes greenish white, fresh specimens with brilliant metallic luster, vertex with faint brown dot at tip, and brown ocelli, elytra tinged with greenish, abdomen with faint minute dots at base. The apex of sixth segment in female, tips of pygofer and style, and the tarsal claws blackish.

Length: Female, 3 mm.; male, 2.5 mm.

This species was described from Colorado and is common in western half of Kansas, being taken as far east as Ottawa County in the plains grasses. It has been taken in great numbers by the author and by Dr. Lawson and must be a heavy drain upon the forage value of the range grasses.

Gladionura viridia n. sp.
(Plate V, Fig. 26.)

Resembling *argenteola* but larger, and retaining green color, and differing in genitalia. Head, scarcely wider than pronotum; vertex as long as wide, nearly half longer than pronotum, with a slight depression toward the tip; elytra reaching hind border of second abdominal segment, sub-truncate behind; male tibial spine short, (Text Fig. 1*l*). Ovipositor long, extending one-third its length beyond the pygofer; last ventral segment of female emarginate, and with the border between the lateral angles rather distinctly sinuate and about half as long as lateral angles. Male pygofer elongate, narrowed from the middle, and extending into a long process sharply hooked at tip; valve triangular, about half as long as plates; plates large, broad, covering sides of pygofer, divergent, apex acute; styles flat, broadly expanded at tip into three broad lobes. Aedeagus rather short and broad, slightly curved, deeply emarginate on inner tip. (See Fig. 44).

Color: Grass green, persisting in the dried specimens, with very minute dark dots. Vertex with a black dot each side at base; ocelli black; frontal arcs pale; elytra hyaline, suffused with green; abdomen with a series of fine dots at base; ovipositor tipped with brown; venter mostly green; border of the female segment, base of valve, style and aedeagus, black.

Length: Female, 4 mm.; male, 3 mm.

Described from a series of specimens, (types and paratypes), seven females, six males, collected at Montgomery County, Kansas, Aug. 3, 1923, (Beamer-Lawson) and kindly forwarded by Doctor Lawson. (National Museum Type No. 43191.) This belongs to the *argenteola* group but has a very distinct difference in the male styles and a somewhat different outline for the female segment.

Gladionura extensa n. sp.
(Plate VII, Fig. 46.)

Apparently nearly related to *argenteola*, but distinguished by the enormously elongated pygofer which forms a strong hook. Head broad; vertex short, a little longer than pronotum, scarcely angular, faintly depressed near the base, but not at tip, polished; pronotum concave. Elytra reaching to tip of second abdominal segment. Male pygofer broad at base, narrowing abruptly beyond the middle, and extended into a very long process, curved at the tip; valve long, angular; plates elongate, rather narrow, tips bluntly angular; styles much swollen toward the tip, incurved; aedeagus thin, curved, emarginate on inner tip. (Fig. 46).

Color: Light gray, with very distinct fuscous markings, the vertex with two large round black dots, a small dot at apex, and an interrupted transverse band with two minute oblique bands at base. Pronotum with three pairs of dots anteriorly, and three short stripes posteriorly, the middle one continued on the scutellum. Elytra with distinct fuscous stripes in the cells. Abdomen with the usual dots and stripes well-marked; beneath darker; the face with short arcs and an interrupted double stripe on the middle, a large dot just outside the loræ, and the sutures black.

Described from one specimen, male (type) Delphos, Kansas, collected by the writer, April, 1910. Possibly the females are not easily distinguished from *argenteola*.

Gladionura nacazarana n. sp.
(Plate III, Fig. 15.)

Similar to *argenteola* but slightly larger with shorter vertex and with quite different genitalia; head wider than pronotum; vertex as long as wide, one-fourth longer than pronotum; pronotum sinuate; elytra short, reaching on to second segment, convex behind. Male tibia with a long slender spur, (Text Fig. 1g). Female, ovipositor long one-third longer than pygofer, last segment emarginate, the middle section not produced: Male pygofer short, sloping, tip produced into a sharp point; valve long, angled behind; plates large, outer angle acute; styles rather slender, obtusely pointed; aedeagus short.

Color: Pale gray, suffused with yellowish in the female, pinkish in the male; vertex with faint brown dots over ocelli; abdomen with minute blackish dots in the usual series, mostly obsolete in the male; disc of venter, base of male valve, tips of pygofer, styles and aedeagus, black.

Length: Female, 3.75 mm.; male, 2.75 mm.

Described from two specimens, holotype (female) and allotype (male) in Osborn collection, collected at Nacazara, Mexico, July 25, 1907, by J. S. Hine. The difference in color is, I

believe, simply a variation as in all other respects these two specimens collected at the same time appear to agree perfectly in structure.

EXPLANATION OF FIGURES IN THE PLATES.

Plate I.

Fig. 1. *Amphipyga acuticauda:* 1*a*, nymph; 1*b*, brachypterous female; 1*c*, vertex and pronotum; 1*d*, female; 1*e*, male genitalia, lateral view; 1*f*, ventral view; 1*g*, another lateral view; 1*h*, elytra macropterous, female.

Fig. 2. *Amphipyga occidentalis:* dorsal view macropterous female: 2*a*, face; 2*b*, vertex and pronotum; 2*c*, female; 2*d*, male lateral; 2*e*, vental view genitalia; 2*f*, elytron.

Fig. 3. *Amphipyga balli*, vertex and pronotum: *b*, female; *c*, male lateral; *d*, ventral view genitalia.

Fig. 4. *Amphipyga aridella:* *a*, vertex and pronotum; 4*b*, female; *c*, male lateral; *d*, ventral view.

Plate II.

Fig. 5. *Athysanella attenuata:* *a*, vertex and pronotum; *b*, female; *c*, male lateral; *d*, ventral genitalia.

Fig. 6. *Athysanella terebrans:* *a*, vertex and pronotum; *b*, female; *c*, male lateral; *d*, ventral view genitalia.

Fig. 7. *Amphipyga stylata:* *a*, vertex and pronotum; *b*, female; *c*, male lateral; *d*, ventral view, genitalia.

Fig. 8. *Athysanella extrusa:* *a*, vertex and pronotum; *b*, female; *c*, male lateral; *d*, ventral view, genitalia.

Fig. 9. *Athysanella yumana:* *a*, vertex and pronotum; *b*, female; *c*, male lateral; *d*, ventral view, genitalia.

Fig. 10. *Athysanella gardenia:* *a*, vertex and pronotum; *b*, female; *c*, male lateral; *d*, ventral view, genitalia.

Plate III.

Fig. 11. *Athysanella magdalena:* *a*, face; *b*, vertex and pronotum; *c*, female; *d*, lateral; *e*, ventral view genitalia; *f*, female elytra; macropterous female.

Fig. 12. *Athysanella utahna:* *a*, vertex and pronotum; *b*, female; *c*, male lateral; *d*, ventral view, genitalia.

Fig. 13. *Gladionura sinuata:* *a*, vertex and pronotum; *b*, female; *c*, male lateral; *d*, ventral view, genitalia.

Fig. 14. *Gladionura argenteola:* *a*, vertex and pronotum; *b*, female; *c*, male lateral; *d*, ventral view, genitalia.

Fig. 15. *Gladionura nacazarana:* *a*, vertex and pronotum; *b*, female; *c*, male lateral; *d*, ventral view, genitalia.

Plate IV.

Fig. 16. *Pectinopyga texana*, head: *a*, female; *b*, male lateral view, genitalia.

Fig. 17. *Gladionura recurvata*, vertex and pronotum: *a*, female; *b*, lateral; *c*, ventral, genitalia.

Fig. 18. *Gladionura aridicola*, vertex and pronotum: *a*, female; *b*, lateral; *c*, ventral view male, genitalia.

Fig. 19. *Gladionura emarginata*, vertex and pronotum: *a*, female; *b*, lateral; *c*, ventral view male, genitalia.

Fig. 20. *Gillettiella labiata*, vertex and pronotum: *a*, female; *b*, lateral; *c*, ventral view male, genitalia.

Fig. 21. *Gillettiella atropuncta: a*, dorsal view; *b*, vertex and pronotum; *c*, female; *d*, male lateral; *e*, ventral view, genitalia; *f*, elytron.

PLATE V.

Fig. 22. *Athysanella robusta: a* ♀, vertex; *b*, female; *c*, lateral; *d*, ventral male, genitalia; *e* ♂, vertex.

Fig. 23. *Athysanella montana: a*, vertex; *b*, female; *c*, male side view; *d*, male ventral view, genitalia.

Fig. 24. *Amphipyga alta: a*, vertex; *b*, female; *c*, male genitalia.

Fig. 25. *Gladionura excavata: a*, vertex; *b*, female genitalia.

Fig. 26. *Gladionura viridia: a*, head; *b*, female; *c*, lateral; *d*, ventral view male, genitalia.

Fig. 27. *Gladionura abbreviata: a*, female; *b*, lateral; *c*, ventral view male, genitalia.

PLATE VI.

Internal genitalia of males.

Fig. 28. *Amphipyga acuticauda: a*, lateral; *b*, dorsal view.

Fig. 29. *Amphipyga balli: a*, lateral; *b*, dorsal view.

Fig. 30. *Amphipyga occidentalis: a*, lateral; *b*, dorsal view.

Fig. 31. *Amphipyga aridella: a*, lateral; *b*, dorsal view.

Fig. 32. *Athysanella attenuata: a*, lateral; *b*, dorsal view.

Fig. 33. *Amphipyga stylata: a*, lateral; *b*, dorsal view.

Fig. 34. *Athysanella terebrans: a*, lateral; *b*, dorsal view.

Fig. 35. *Athysanella extrusa: a*, lateral; *b*, dorsal view.

Fig. 36. *Gladionura argenteola: a*, lateral; *b*, dorsal view.

Fig. 37. *Gladionura emarginata: a*, lateral; *b*, dorsal view.

Fig. 38. *Gladionura recurvata: a*, lateral; *b*, dorsal view.

Fig. 39. *Gladionura aridicola: a*, lateral; *b*, dorsal view.

PLATE VII.

Internal genitalia of males.

Fig. 40. *Athysanella yumana: a*, lateral; *b*, dorsal view.

Fig. 41. *Athysanella utahna: a*, lateral; *b*, dorsal view.

Fig. 42. *Athysanella gardenia: a*, lateral; *b*, dorsal view.

Fig. 43. *Gladionura sinuata: a*, lateral; *b*, dorsal view.

Fig. 44. *Gladionura viridia: a*, lateral; *b*, dorsal view.

Fig. 45. *Gladionura abbreviata: a*, lateral; *b*, dorsal view.

Fig. 46. *Gladionura extensa: a*, lateral; *b*, dorsal view.

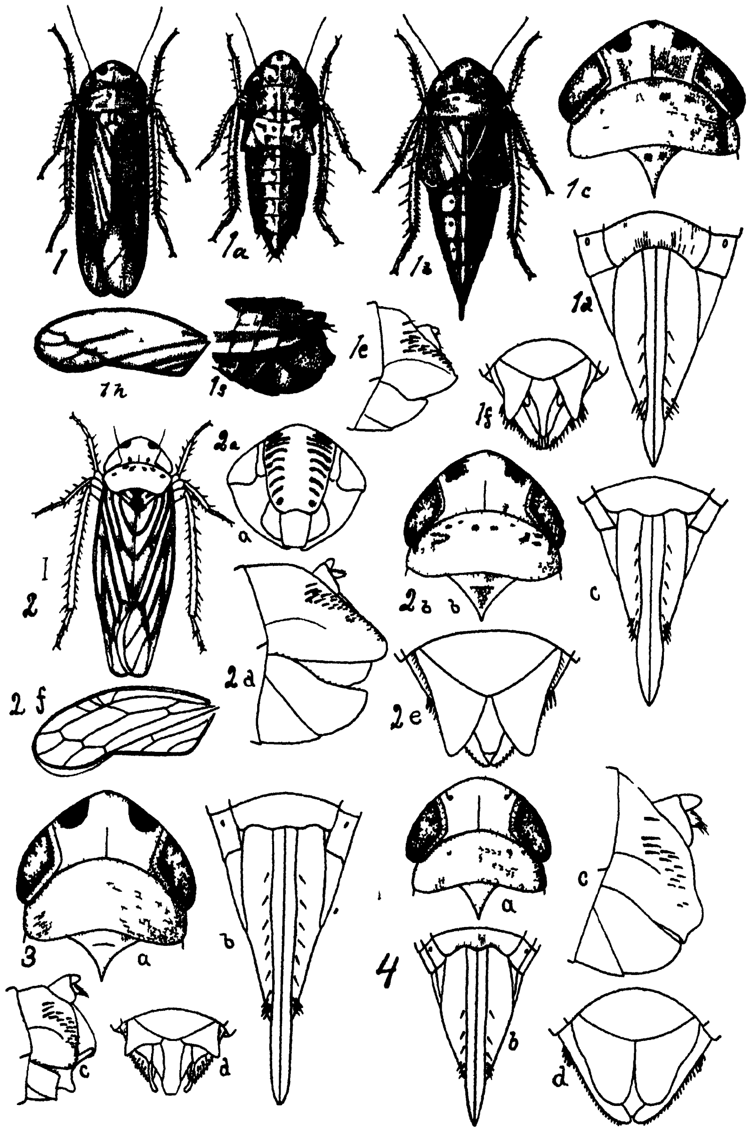
Fig. 47. *Amphipyga alta: a*, lateral; *b*, dorsal view.

Fig. 48. *Pectinapyga texana: a*, lateral; *b*, dorsal view.

Fig. 49. *Amphipyga stylata* var. (?): *a*, lateral; *b*, dorsal view.

Fig. 50. *Gillettiella labiata: a*, lateral; *b*, dorsal view.

Fig. 51. *Gillettiella atropuncta: a*, lateral; *b*, dorsal view.


1
1a
1b
1c
1d
1e
1f
1g
1h
2
2a
a
2b
b
c
2d
2e
2f
3
a
b
c
d
4
a
b
c
d

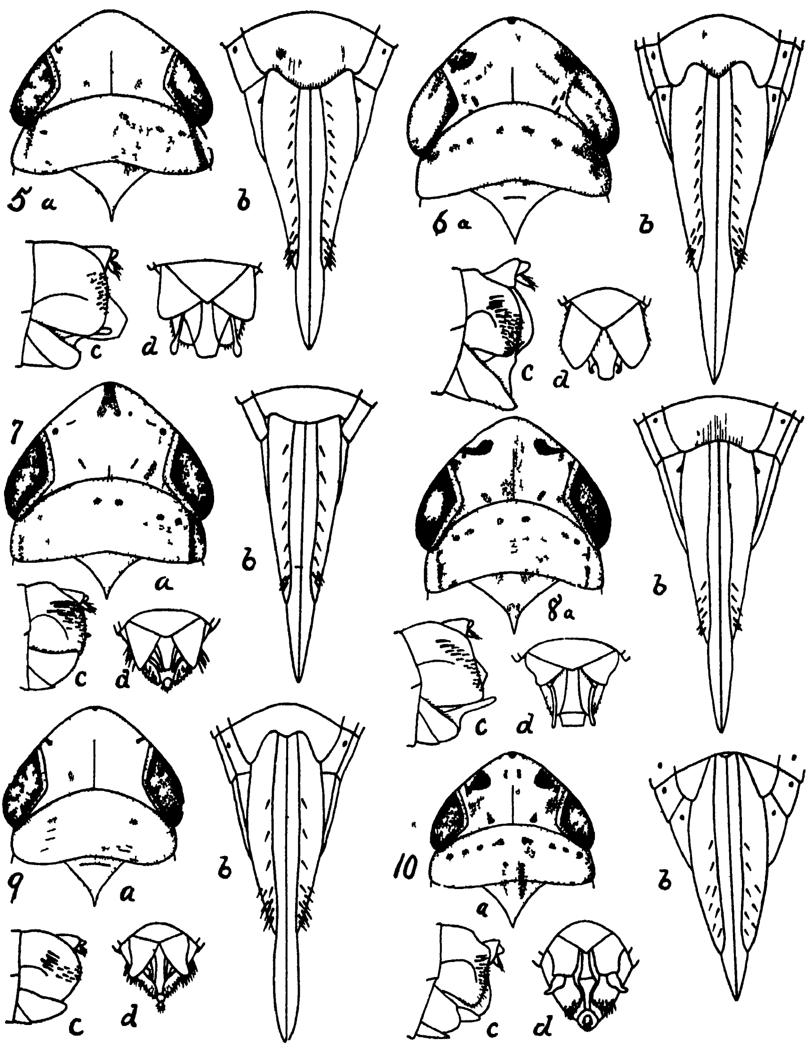
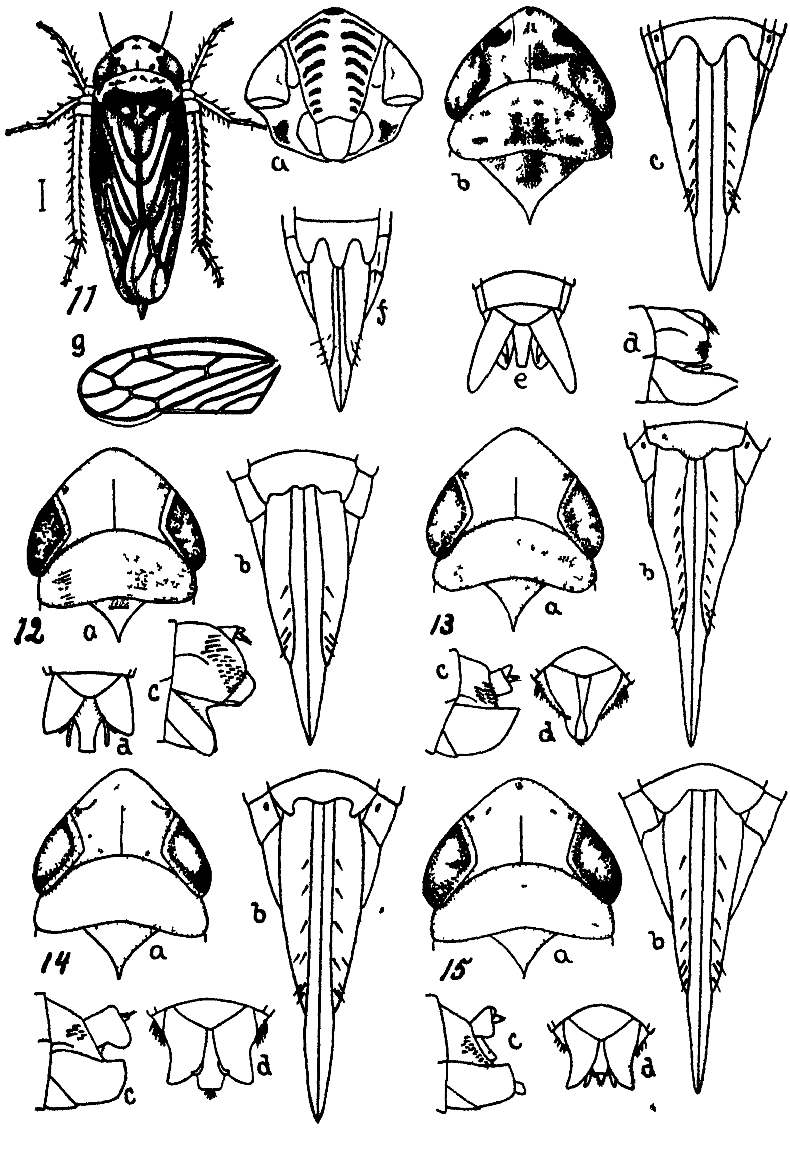
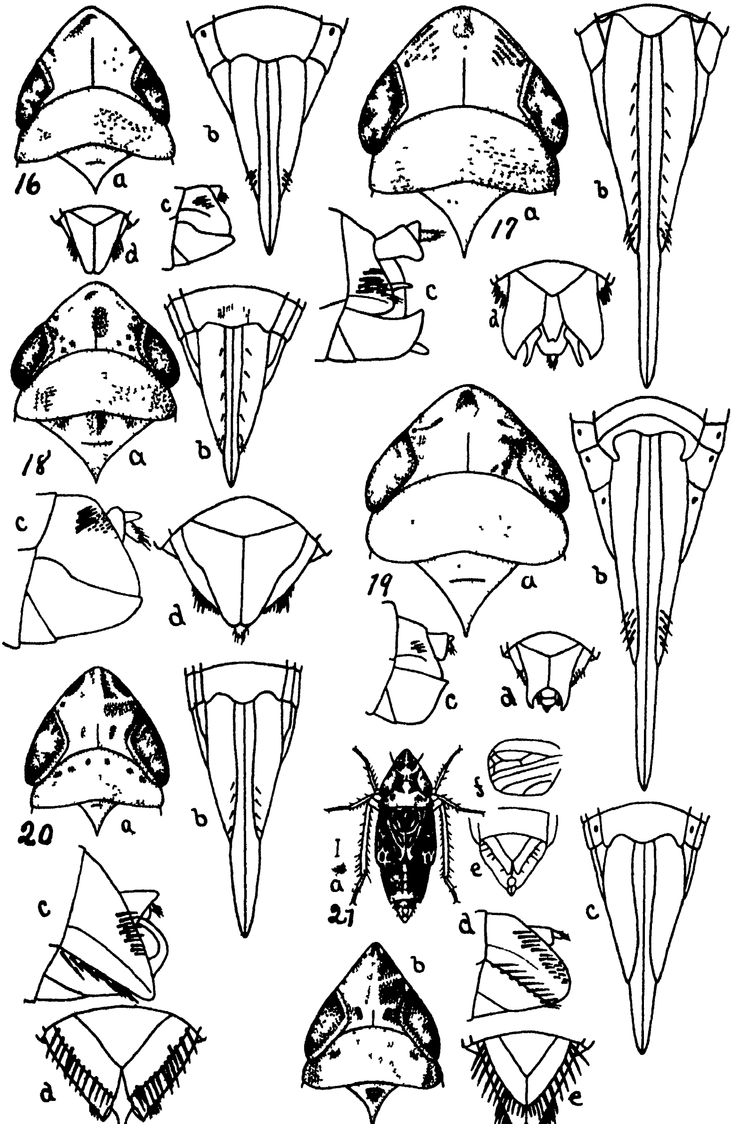
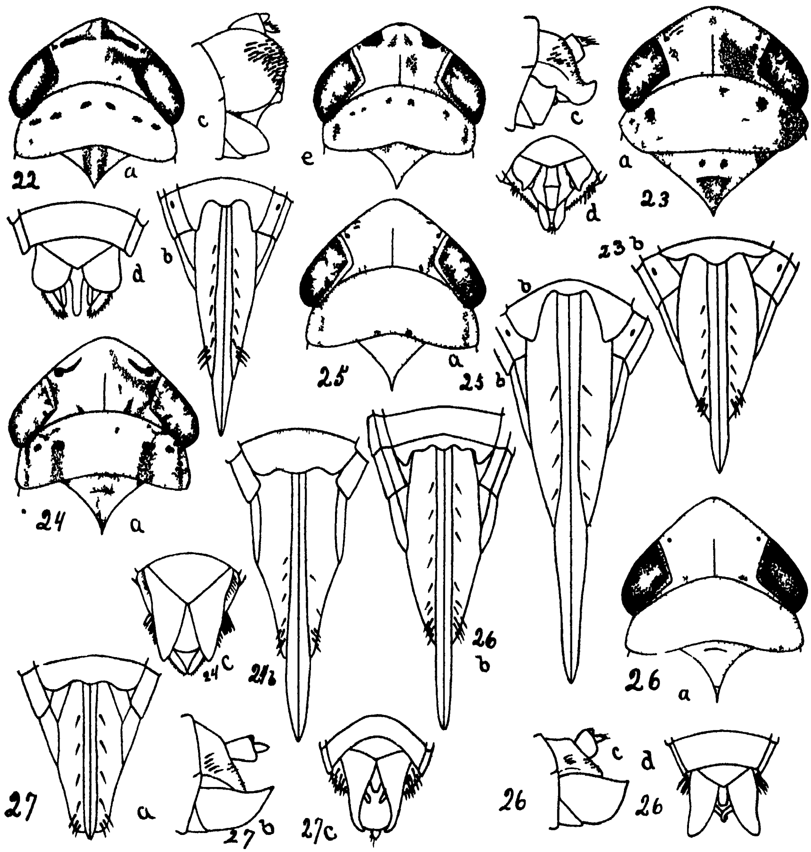
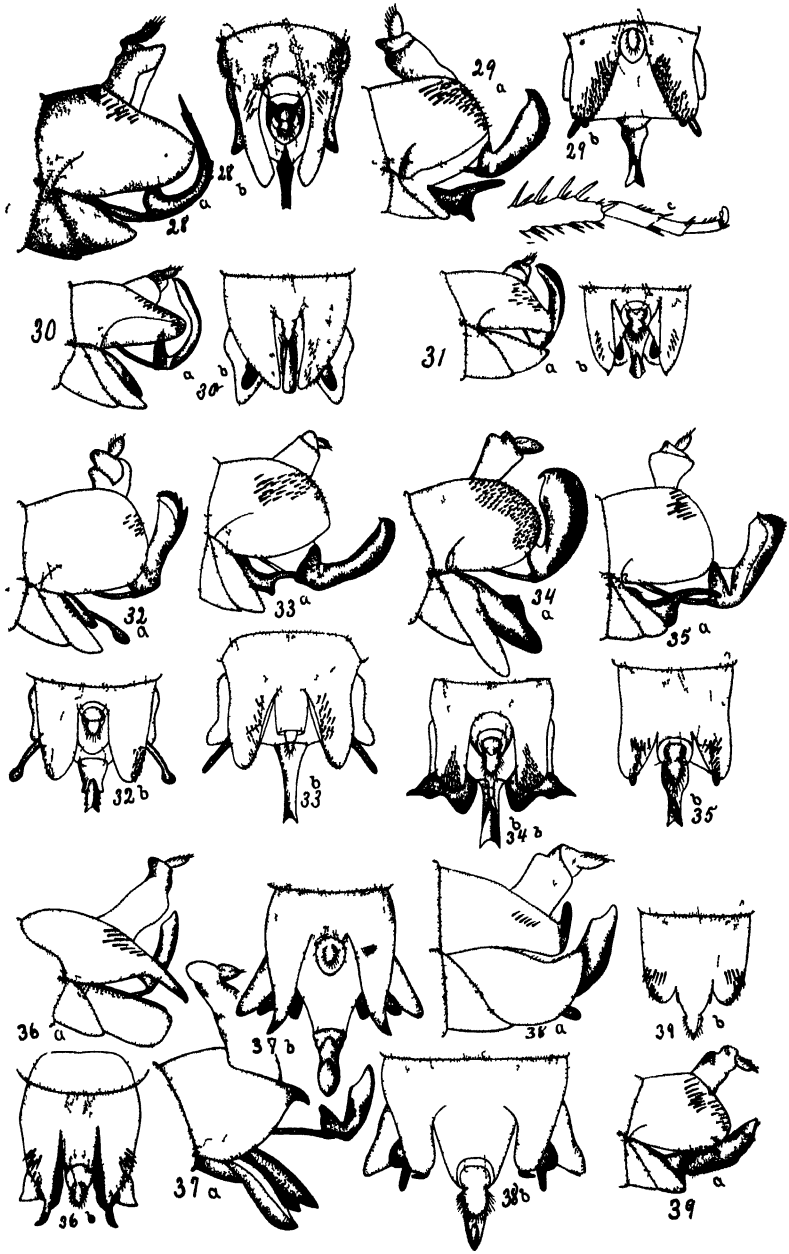

5 a
b
c
d
6 a
b
c
d
7
a
b
c
d
8 a
b
c
d
9
a
b
c
d
10
a
b
c
d

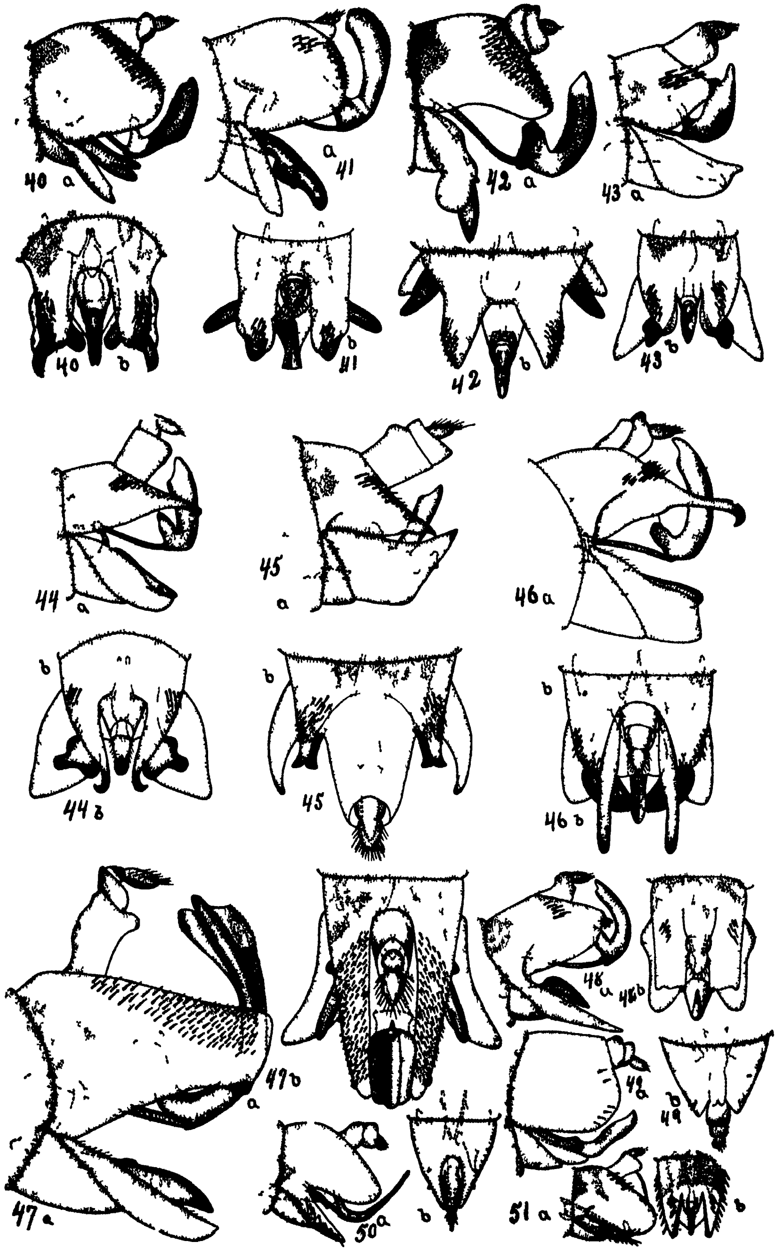
PLATE III.




16
a
b
c
d
17
a
b
c
d
18
a
b
c
d
19
a
b
c
d
20
a
b
c
d
21
a
b
c
d
e
f
e


22
a
c
e
c
d
a
23
d
b
23 b
b
25
a
25 b
24
a
24 c
24 b
26
b
26
a
27
a
27 b
27 c
26
c
d
26


28 a
28 b
29 a
29 b
c
30 a
30 b
31 a
b
32 a
33 a
34 a
35 a
32 b
33 b
34 b
35 b
36 a
37 b
38 a
39 b
36 b
37 a
38 b
39 a


40 a
41 a
42 a
43 a
40 b
41 b
42 b
43 b
44 a
45 a
46 a
44 b
45 b
46 b
47 a
47 b
48 a
48 b
49 a
49 b
50 a
b
51 a
b

NEW SPECIES OF CRANE FLIES FROM SOUTH AMERICA. PART IV.*†

(Family Tipulidæ, Order Diptera.)

CHARLES P. ALEXANDER,
Amherst, Massachusetts.

The majority of the species discussed at this time were collected in *Bolivia* by Mr. Schade, and in *Colombia* by Messrs. George Salt and Fred W. Walker. Fewer specimens are from *Brazil*, collected by Messrs. Davis and Shannon and from *British Guiana*, collected by Miss Alice Mackie, kindly sent to me by Professor Cockerell, and by Dr. John G. Myers. A beautiful new species of *Eriocera* from Brazil was contained in the collections of the Deutsches Entomologisches Museum and sent to me for naming by Dr. Walther Horn. I wish to express my sincere thanks to all the above entomologists for this kindly co-operation. Where not stated to the contrary, the types of the novelties are preserved in my collection. Only a small part of the collections made by Mr. Walker on Mt. Santa Marta are discussed at this time, the remainder being reserved for consideration in a later article. This important collection is the property of the Museum of Zoology of the University of Michigan and was loaned to me for study through the kindness of Professor J. Speed Rogers.

Limonia Meigen.

Limonia (Limonia) splendidula sp. n.

General coloration black, the body pruinose with gray and yellowish gray areas; halteres yellow, the knobs black; femora yellow, each with a conspicuous black subterminal ring; wings whitish hyaline, the prearcular, costal and subcostal regions yellow; a conspicuous dark brown reticulate pattern, distributed chiefly in the radial and medial fields; *m-cu* nearly its own length before the fork of *M*.

*Contribution from the Entomological Laboratory, Massachusetts Agricultural College.

†The preceding part under this general title was published in these ANNALS in 1929 (XXII: 768–788).

Female.—Length about 8 mm.; wing, 8 mm.

Rostrum approximately one-half the length of the remainder of head, black, the palpi concolorous. Antennal scape brownish black; flagellum dark brown, the basal segments and incisures of the succeeding segments reddish brown; flagellar segments subglobular to short-oval, the outer segments more elongate; terminal segment subequal to the penultimate. Anterior vertex golden-gray, the posterior vertex more brownish gray; a brownish spot near center of the posterior vertex.

Pronotum brownish black, with a grayish golden pollen. Mesonotal praescutum with the median region dark brown, the area broadened behind by fusion with the lateral stripes; humeral region brown with a heavy golden-gray pollen, the latter best developed as an oval area behind the pseudosutural foveæ; scutal lobes extensively dark brown or black, the median area paler; scutellum and postnotum brownish black, the surface sparsely pruinose. Pleura black, the surface with a dense yellowish gray pollen, lacking on portions of the sternopleurite and anepisternum. Halteres yellow, the knobs black. Legs with the coxæ and trochanters brownish black; femora yellow, with a conspicuous black subterminal ring; tibiæ brownish yellow, the bases and tips blackened, the latter a little more broadly so; tarsi black. Wings whitish hyaline, the prearcular, costal and subcostal regions clearer yellow; a conspicuous dark brown pattern, arranged chiefly in the radial and medial fields, elsewhere appearing as narrow apical seams to the veins and in the axillary region; most of the areas are geminate, appearing as margins to pale centers that are of exactly the same color as the ground of the wing, the whole producing a reticulate appearance; veins brown, *C*, *Sc*, *R* and *Cu* more yellowish. Venation: Sc_1 ending about opposite midlength of *Rs*, Sc_2 near its tip; R_2 and free tip of Sc_2 about in alignment; *m-cu* nearly its own length before the fork of *M*.

Abdominal tergites brownish black; sternites more grayish pruinose, with a narrow blackish median stripe that is nearly continuous. Ovipositor with the valves reddish horn-color; tergal valves relatively small, gently upcurved.

HABITAT: Bolivia. *Holotype*, ♀, Santa Cruz, February, 1929 (ex Fr. Schade).

Limonia splendidula is allied to *L.* (*L.*) *elegantula* (Alexander) of Colombia, differing especially in the coloration of the wings and legs.

Limonia (Limonia) sanctæ-martæ sp. n.

General coloration yellow; mesonotal praescutum with a broad dark brown median stripe; femora blackened at bases and just before tips; wings yellow with a restricted dark brown pattern; stigma and an extensive clouding in cell R_3 paler brown; *Sc* long; *Rs* angulated and spurred at origin; outer abdominal tergites bicolorous, the sternites yellow.

Female.—Length about 9 mm.; wing, 11 mm.

Rostrum and palpi black. Antennæ with the basal segment black, flagellar segments oval, pale brown, the verticils exceeding the segments. Head brownish black, the anterior vertex more grayish, reduced to a narrow strip.

Pronotum dark brown medially, light yellow laterally. Mesonotal praescutum yellow with a broad dark brown median stripe that extends to the suture; scutum obscure brownish yellow, the mesal edge of each lobe dark brown; scutellum and postnotum dark brown, the surface weakly pruinose. Pleura, including the pleurotergite, uniformly pale yellow. Halteres pale yellow, the knobs weakly infuscated. Legs with the coxæ and trochanters yellow; femora broadly blackened basally, thence paling to brownish yellow, at near apex again broadly blackened, preceded by a vague brighter yellow ring; extreme tips of femora and bases of tibiæ whitened; remainder of tibiæ brown, the tips somewhat darker; tarsi black, the terminal segments broken. Wings yellow, clearer yellow in the costal region, with longitudinal pale streaks in cells *R*, *M* and *Cu;* a restricted dark brown pattern, appearing as narrow seams at origin of *Rs*, fork of *Sc*, cord, outer end of cell *1st* M_2, fork of R_1 and as narrow seams back from the margin of all longitudinal veins; stigma paler brown, delimited at outer end by the dark seam at fork of R_1; cell R_3 and caudal portion of R_2 suffused with pale brown; veins pale yellow, dark brown in the infuscated areas. Venation: *Sc* long, Sc_1 ending about opposite two-thirds the length of *Rs*, Sc_2 at its tip; *Rs* long, angulated and weakly spurred at origin; inner end of cell R_3 lying considerably proximad of cell R_5; inner end of cell *1st* M_2 pointed; *m-cu* shortly before the fork of *M*.

Abdominal tergites bicolorous, the bases yellow, the apices brown, the basal segments more uniformly darkened; sternites yellow. Ovipositor with the tergal valves relatively small and slender, gently upcurved; sternal valves stout and straight, reddish horn-color, blackened at base.

HABITAT: Colombia. *Holotype*, ♀, La Cumbre, Mt. Santa Marta, in open clearing, altitude 7,500 feet, August 8, 1926 (F. W. Walker). Type to be preserved in the Museum of Zoology, University of Michigan.

Limonia sanctæ-martæ is very distinct from all described regional species.

Limonia (Dicranomyia) boliviana sp. n.

Allied to the Mexican *L.* (*D.*) *filicauda* (Alexander), differing especially in the details of structure of the male hypopygium.

Male.—Length about 7 mm.; wing, 7.2 mm.

Rostrum and palpi black. Antennæ with the scape obscure yellow, the flagellum black. Head light gray.

Pronotum yellow. Mesonotal praescutum brownish gray, with three darker brown stripes, the lateral pair less distinct; scutal lobes and scutellum dark, with a narrow pale median vitta; postnotum dark, sparsely pruinose. Pleura gray. Halteres very long and slender, as in the group, pale, the knobs infuscated. Legs with the coxæ and trochanters yellow; femora yellowish brown, the tibiæ and tarsi passing through dark brown to black. Wings suffused with brown, the oval stigma slightly darker brown; veins brown. Venation: Sc_1 ending opposite the origin of *Rs*, Sc_2 some distance from its tip, Sc_1 alone being about two-thirds *Rs*; *m-cu* close to fork of *M*, subequal to the distal section of Cu_1.

Abdomen dark brown, the basal sternites slightly paler. Male hypopygium with the caudal margin transverse or nearly so, with numerous setæ, including two more powerful setæ on either side of the median line close to the margin. Basistyle with very complex ornamentation, as in *filicauda*, including a long pale fleshy lobe. Dorsal dististyle a very slender, nearly straight rod. Ventral dististyle with the rostral prolongation long and conspicuous, the two rostral spines subequal in length, closely appressed to the prolongation; a conspicuous hairy oval lobe at the axil of the prolongation.

HABITAT: Bolivia. *Holotype*, ♂, Santa Cruz, February, 1929 (ex Fr. Schade).

The much longer filiform lobes of the hypopygium in *filicauda* seem to be borne by the tergite rather than by the basistyle, as is the case in *boliviana*.

Limonia (Geranomyia) bahiensis sp. n.

Rostrum and antennæ entirely black; mesonotal praescutum with three narrow brown stripes, the median one darker; knobs of halteres black; femora with the tips broadly yellow, enclosing a narrow dark brown subterminal ring; wings grayish yellow, with a sparse brown pattern; Sc_1 extending a short distance beyond origin of *Rs;* male hypopygium with caudal margin of the tergite very gently emarginate; rostral spines subequal in length, arising from slightly unequal basal tubercles, placed on the face of the rostral prolongation at base.

Male.—Length (excluding rostrum) about 5.5 mm.; wing, 6.5 mm.; rostrum about 2.5 mm.

Rostrum and palpi black. Antennæ black throughout. Head yellowish gray with two narrow black lines on the vertex that enclose a narrower median area of the ground-color.

Mesonotal praescutum obscure ochreous, with three narrow brown stripes, the median stripe darker brown, the lateral stripes more reddish brown, paler behind; lateral margins of praescutum likewise slightly darkened; scutum pale brown, the cephalic and mesal portions of each

lobe narrowly darker brown; scutellum and postnotum pale, vaguely marked with darker. Pleura obscure yellow, the anepisternum and dorsopleural region slightly darker. Halteres dark brown, the stem chiefly pale yellow. Legs obscure yellow, the fore coxæ a trifle darkened; femora obscure brownish yellow, the tip broadly pale yellow, enclosing a narrow dark brown ring that is a little wider than the yellow apical portion beyond; tibiæ obscure yellow, the tips narrowly brownish black; basitarsi obscure yellow, the outer tarsal segments dark brown. Wings grayish yellow, the costal region in cells *C* and *Sc* brighter yellow; a sparse brown pattern, arranged as follows: A subcostal series of three areas, the last a common spot that includes the tip of *Sc* and the origin of *Rs*; stigma small; conspicuous pale brown seams and clouds along cord, outer end of cell *1st* M_2 and as marginal seams on the Anal veins; veins pale brown, *Sc*, *R* and *Cu* chiefly yellowish. Venation: A supernumerary crossvein in cell *Sc* at near midlength; Sc_1 ending shortly beyond origin of *Rs*, Sc_2 at its tip; *Rs* weakly angulated at origin; *m-cu* shortly before the fork of *M*.

Abdomen brown. Male hypopygium with the tergite transverse, the caudal margin only weakly emarginate, the low lateral lobes densely setiferous. Dorsal dististyle widest at near midlength, somewhat angularly bent, gradually narrowed to a long acute point. Ventral dististyle large and fleshy, the rostral prolongation long and slender, yellow, with the two rostral spines arising on the side at the base, subequal in length from slightly unequal basal tubercles. Gonapophyses with the mesal apical lobe entirely pale, long, slender, narrowed gradually to nearly acute points.

HABITAT: Brazil. *Holotype*, ♂, Bahia, stream-pool, March, 1929 (Davis and Shannon).

The present fly is allied to Neotropical species like *L.* (*G.*) *inaequituberculata* Alexander (Paraguay) and *L.* (*G.*) *platensis* Alexander (Argentina), differing from all known species in the details of structure of the male hypopygium.

Limonia (Geranomyia) guianensis sp. n.

General coloration of mesonotum reddish, with three narrow dark brown stripes, the interspaces more silvery; antennal flagellum yellowish brown; legs yellow, the femora with a vague dark subterminal ring; wings yellow, sparsely variegated with brown; *Sc* relatively short; cell *1st* M_2 longer than any of the veins beyond it; male hypopygium with the ventral dististyle large and fleshy, the spines arising from the face of style at base of the prolongation; mesal apical lobe of gonapophysis darkened, spinous.

Male.—Length (excluding rostrum) about 4 mm.; wing, 4.6 mm.; rostrum about 1.9 mm.

Rostrum relatively short, black, the tips of the labial palpi obscure yellow. Antennæ with the scape black, the flagellum yellowish brown; basal flagellar segments short-oval, the outer ones more elongate. Head silvery gray, the posterior vertex with two conspicuous black areas that enclose a narrower linear strip of the ground-color; anterior vertex narrow, more yellowish white.

Mesonotal praescutum reddish gray, with three narrow dark brown stripes, the interspaces more silvery gray; lateral margins of praescutum broadly but vaguely darkened; median region of scutum whitish, the lobes darkened, especially their mesal margin; scutellum weakly darkened, narrowly pale medially at base; postnotal mediotergite brownish testaceous with a capillary impressed median line. Pleura chiefly plumbeous, the dorsal pleural region and pteropleurite paler. Halteres yellow, the knobs weakly darkened. Legs with the coxæ and trochanters yellow; femora obscure yellow with a vague diffuse darker subterminal ring that is wider than the pale apex; a narrow subobsolete yellow ring before the darkened annulus; tibiæ and tarsi obscure yellow, the latter passing into dark brown at tips. Wings with a yellow ground-color, the prearcular and costal regions brighter yellow; a restricted dark pattern, including four subcostal areas, the first just beyond *h*, the second at the supernumerary crossvein, the third a common area at origin of *Rs* and fork of *Sc*, the last stigmal; wing-apex broadly but vaguely darkened; narrow paler seams along cord, outer end of cell *1st* M_2 and along vein *2nd A;* veins pale yellow, darker in the infuscated areas. Venation: *Sc* short, Sc_1 ending just beyond origin of *Rs*, Sc_2 at its tip; *Rs* weakly angulated at origin; cell *1st* M_2 longer than any of the veins beyond it; *m-cu* close to the fork of *M*.

Abdomen brownish yellow, the segments more darkened basally; subterminal segments more uniformly infuscated; hypopygium chiefly brownish yellow. Male hypopygium with the ninth tergite transverse, the caudal margin with a conspicuous U-shaped median notch. Ventral dististyle very large and fleshy, exceeding twice the size of the basistyle and its lobe; rostral prolongation slender, the spines arising from the face of the style at its base; spines slightly unequal, arising from conspicuous subequal basal tubercles. Dorsal dististyle a strongly curved sickle. Gonapophyses with the mesal apical lobe a relatively short dusky spine, narrowed to the acute tip.

HABITAT: British Guiana. *Holotype*, ♂, Koriabo, Barima River, May 5, 1929 (J. G. Myers).

Limonia (*Geranomyia*) *guianensis* is closest to *L.* (*G.*) *scolopax* (Alexander), differing in the diagnostic features listed above.

Limonia (Geranomyia) marthæ sp. n.

General coloration gray, the praescutum more brownish gray, with three narrow black lines; rostrum about as long as the combined head and thorax; femora paling to yellow at

tips, this area enclosing a broad dark brown subterminal ring; wings subhyaline, with a very restricted dark pattern; a supernumerary crossvein in cell *Sc; Sc* short, Sc_1 ending shortly beyond the origin of *Rs;* cell *1st* M_2 long; male hypopygium with the tergite deeply notched medially; ventral dististyle large and fleshy; rostral spines subequal but arising from very unequal basal tubercles.

Male.—Length (excluding rostrum) about 6.5 mm.; wing, 7 mm.; rostrum about 2.5 mm.

Female.—Length (excluding rostrum) about 7 mm ; wing, 7 mm.; rostrum about 3 mm.

Rostrum of moderate length, as shown by the measurements, subequal to the combined head and thorax, dark brown. Antennæ black throughout: flagellar segments oval. Head yellowish gray, the posterior vertex with a blackish area on either side of the midline.

Mesonotum gray, the praescutum more brownish gray, with three narrow velvety black lines; scutum gray, the mesal edge with a narrow black line, this being a caudal prolongation of the lateral praescutal stripe; scutellum and postnotum clearer gray. Pleura dark gray. Halteres relatively short, pale, the knobs infuscated. Legs with the coxæ and trochanters yellow; femora brownish yellow, the apex paling to yellow, this enclosing a broad brown ring that is much wider than the yellow areas enclosing it; tibiæ and tarsi brown. Wings subhyaline with a very sparse dark pattern, including restricted clouds at the supernumerary crossvein, origin of *Rs* and fork of *Sc*, the stigma and narrow seams along the cord and outer end of cell *1st* M_2; wing-apex broadly and distinctly grayish brown; veins pale, darker in the infuscated areas. Venation: *Sc* short, Sc_1 ending just beyond the origin of *Rs*, Sc_2 at its extreme tip; a supernumerary crossvein in cell *Sc;* cell *1st* M_2 elongate, the second section of M_{1+2} about one-fourth longer than the last section; *m-cu* close to the fork of *M*.

Abdomen dark grayish brown, the caudal margins of the segments insensibly paler; basal sternites obscure yellow; male hypopygium dark, the ventral dististyle paler. Male hypopygium with the ninth tergite deeply notched medially, the lobes thus formed broadly obtuse, with abundant setæ. Basistyle small, the ventro-mesal lobe conspicuous Ventral dististyle very large and fleshy, its extent three or four times that of the basistyle; rostral prolongation slender, arcuated, the spines arising from its base, one from a small basal tubercle that is about one-third to one-fourth the length of the spine, the other from an elongate tubercle that is only a little shorter than the spine itself, the actual spines nearly equal in length. Dorsal dististyle a strongly curved yellow hook. Gonapophyses with the mesal apical lobe appearing as a stout curved yellow point.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude 5,000 feet, August 6, 1925 (F. W. Walker).

Allotopotype, ♀, August 8, 1926, at light, 4 A. M. (F. W. Walker).

Type to be preserved in the Museum of Zoology, University of Michigan.

Limonia (*Geranomyia*) *marthæ* is readily told by the combination of characters outlined above. The general coloration is much as in *cinereinota* (Alexander), but the species is more nearly allied to *plumbeipleura* (Alexander) and allied forms.

Limonia (Geranomyia) versuta sp. n.

General coloration gray, the praescutum with three narrow black stripes; halteres yellow, the knobs infuscated; femora brown, the tips very imperceptibly paler; wings whitish subhyaline, with a very restricted dark pattern; *Sc* short; male hypopygium with the tergite deeply notched medially; ventral dististyle relatively small, the rostral prolongation short and stout, with two spines, one arising from a stout broad-based tubercle.

Male.—Length (excluding rostrum) about 5.5 mm.; wing, 7 mm.; rostrum about 2.8 mm.

Rostrum and palpi black. Antennæ dark brown; flagellar segments short-oval, with inconspicuous verticils. Head gray, the posterior vertex with a narrow black line on either side of the median vitta.

Pronotum brownish gray, with a median and lateral black stripes. Mesonotal praescutum gray with a faint brown tinge, with three narrow black stripes; posterior sclerites of mesonotum gray, the mesal edge of each scutal lobe with a narrow black line, this being a backward continuation of the lateral praescutal stripe. Pleura brownish gray, the dorsal sternopleurite somewhat paler. Halteres yellow, the knobs infuscated. Legs with the coxæ yellowish testaceous, the fore coxæ more infuscated; trochanters yellowish testaceous; femora obscure yellow at base, soon passing into dark brown, the tips very imperceptibly paler; tibiæ brown, the tips passing into black; tarsi black. Wings whitish subhyaline, with a very restricted dark pattern; stigma very pale brown; restricted slightly darker brown clouds at the supernumerary crossvein, tip of *Sc* and origin of *Rs*, and as very vague clouds along the cord, outer end of cell *1st* M_2 and at ends of longitudinal veins; veins yellow, somewhat darker in the infuscated areas. Venation: *Sc* short, Sc_1 ending before origin of *Rs*, Sc_2 at its tip; a supernumerary crossvein in cell *Sc* at near midlength; distal section of R_5 arcuated just beyond origin; cell *1st* M_2 about as long as the longest vein beyond it; *m-cu* just before the fork of *M*.

Abdominal tergites dark brown, the basal sternites pale yellow; hypopygium dark. Male hypopygium with the tergite deeply notched medially, the conspicuous lateral lobes bluntly rounded, provided with

coarse setæ. Basistyle with the ventro-mesal lobe conspicuous, with long setæ. Ventral dististyle relatively small, not exceeding twice the size of the basistyle; rostral prolongation very short and stout, with two spines, one arising from a stout basal tubercle whose base occupies about one-half the total length of the prolongation; second spine sessile or from a very inconspicuous tubercle, situated at the base of the first. Gonapophyses with the mesal apical lobe appearing as a flattened blade.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude 5,000 feet, August 8, 1926 (F. W. Walker). Type to be preserved in the Museum of Zoology, University of Michigan.

The general appearance of *Limonia* (*Geranomyia*) *versuta* is much like *L.* (*G.*) *cinereinota* (Alexander), but the fly is very distinct in the longer rostrum and structure of the male hypopygium.

Limonia (Geranomyia) neonumenius sp n.

General coloration of praescutum gray with three reddish brown stripes, the sublateral portions further darkened; femora yellow with a subterminal dark brown ring; wings sandy, with a restricted dark pattern; *Sc* long, Sc_1 ending about opposite midlength of *Rs*; male hypopygium with the rostral prolongation of the ventral dististyle short and stout, with two slender gently curved spines placed close to tip.

Male.—Length (excluding rostrum) about 8–8.5 mm ; wing, 8–8.5 mm ; rostrum about 5.3–5.5 mm.

Female.—Length (excluding rostrum) about 9 mm ; wing, 8.5 mm ; rostrum about 5.3 mm.

Rostrum elongate but still shorter than in *numenius*, black, including the maxillary palpi. Antennæ black throughout; flagellar segments cylindrical, the verticils relatively inconspicuous. Head behind blackish, the anterior vertex and an equally wide line on the posterior vertex light gray.

Pronotum brown, with two silvery lines. Mesonotal praescutum with the ground-color silvery gray, with three reddish brown stripes, in addition to the sublateral darkening; median stripe narrower but not darker than the laterals; sublateral ground stripes more yellowish gray; scutum with the median area silvery, the lobes darkened; scutellum chiefly pale, a little infuscated at base; postnotum light brown, sparsely pruinose. Pleura testaceous yellow or brownish yellow. Halteres pale, the knobs weakly infuscated. Legs with the coxæ and trochanters testaceous or slightly tinged with green; femora yellow, the distal fourth brighter yellow, enclosing a narrow dark brown ring that is subequal to the yellow apex; tibiæ obscure yellow, the tips weakly

darkened; tarsi greenish yellow, passing into dark brown; claws (♂) with three long teeth. Wings with the ground-color light sandy or cream-color, the prearcular and costal regions clearer yellow; a restricted pale brown pattern, including clouds at the supernumerary crossvein, origin of *Rs*, fork of *Sc*, stigma and as seams along the cord and outer end of cell *1st* M_2; veins yellow, darker in the infuscated areas, *2nd A* dark. Venation: *Sc* long, Sc_1 ending opposite or shortly beyond midlength of *Rs*, Sc_2 not far from its tip; a supernumerary crossvein in cell *Sc*; cell *1st* M_2 relatively large, approximately as long as M_{1+2} beyond it; *m-cu* at or just beyond the fork of *M*.

Abdominal tergites brown, vaguely variegated with paler; sternites more yellowish; hypopygium reddish brown. Male hypopygium with the tergite transverse, shallowly notched medially, the low lateral lobes conspicuously setiferous. Basistyle with the ventral-mesal lobe long. Ventral dististyle large and fleshy, the rostral prolongation short and stout, with two slender spines placed close to its tip; neither spine from basal tubercles, subequal in length, very gently curved. Gonapophyses with the mesal apical lobe narrowed to a curved blackened spine. Aedeagus long, constricted at near midlength, the apex simple.

HABITAT: Columbia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude 5000 feet, August 8, 1926, at light, 4 A. M. (F. W. Walker). *Allotopotype*, ♀, August 6, 1929. *Paratopotype*, ♂, with the holotype. Type to be preserved in the Museum of Zoology, University of Michigan.

Limonia (*Geranomyia*) *neonumenius* is closest to *numenius* (Alexander), differing in the coloration of the thorax and details of venation, as the larger cell *1st* M_2. I have never seen a male of *numenius*.

Limonia (Geranomyia) walkeri sp. n.

Mesonotal praescutum grayish white, with two reddish brown stripes in addition to the darkened lateral margin; femora with a subterminal brown ring; wings creamy-yellow with a conspicuous darker pattern, including dark marginal seams on all the posterior longitudinal veins; *Sc* relatively long, Sc_1 ending about opposite one-third the length of *Rs*; male hypopygium with the rostral prolongation of the ventral dististyle bearing a single very long spine from a slender basal tubercle.

Male.—Length (excluding rostrum) about 6 mm.; wing, 7 mm.; rostrum about 3.8 mm.

Female.—Length (excluding rostrum) about 6.5 mm.; wing, 7.5 mm.; rostrum about 4 mm.

Rostrum elongate, if bent backward extending about to opposite one-third the length of the abdomen, black, the outer ends of the labial palpi paler; maxillary palpi black. Antennæ with the scapal segments black, the flagellum dark brown; flagellar segments long-oval to subcylindrical. Head gray, the lateral portions of the posterior vertex blackened, restricting the ground-color to a narrow vitta that is subequal in width to the anterior vertex.

Pronotum yellow above, darkened laterally. Mesonotal praescutum grayish white with two reddish brown stripes, one on either side of a capillary median vitta; lateral margins of the sclerite more broadly darker brown; scutal lobes reddish brown; median region of scutum and the scutellum pale whitish; postnotal mediotergite grayish brown medially, paling to yellowish white on the sides. Pleura chiefly pale yellowish white. Halteres yellow, the knobs infuscated. Legs with the coxæ and trochanters yellowish testaceous; femora brownish yellow, clearer yellow at outer ends, this enclosing a conspicuous dark brown ring that is a little more extensive than the yellow apical portion; tibiæ and tarsi light brown, the outer tarsal segments more darkened. Wings creamy yellow, with a conspicuous darker pattern; prearcular and costal regions clearer yellow, especially cell *Sc*; the darkened areas are as follows: Base of cell *Sc*, at supernumerary crossvein, origin of *Rs* and fork of *Sc*, the two latter areas separated or barely contiguous; stigma; clouds along cord and outer end of cell *1st* M_2; seams back from the margin on veins R_3, M_{1+2}, M_3, M_1, Cu_1 and the Anal veins, the largest on vein *1st A;* veins pale, darker in the infuscated areas. Venation: *Sc* of moderate length, Sc_1 extending to about opposite one-third the length of *Rs*, Sc_2 at its tip; a supernumerary crossvein in cell *Sc*; cell *1st* M_2 subequal to vein M_{1+2} beyond it; *m-cu* at fork of *M*.

Abdominal tergites dark brown, the sternites obscure yellow; male hypopygium brownish black, excepting the conspicuous yellow ventral dististyles. Male hypopygium with the tergite transverse, the caudal margin with a broad, shallow emargination, the lateral lobes thus formed obliquely truncate. Basistyle small, the ventro-mesal lobe large. Ventral dististyle large and fleshy, the rostral prolongation slender, shortly before tip with an elongate basal tubercle that bears a single long curved spine; the tubercle alone is about one-half the length of the dorsal dististyle, while the spine is fully one-half longer than this dististyle. Dorsal dististyle nearly straight on basal two-thirds, thence curved to the tip. Gonapophyses with the mesal apical angle appearing as a very long and nearly straight spine. Aedeagus at tip with two divergent flaps.

HABITAT: Colombia, Brazil. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude 5000 feet, August 8, 1926 (F. W. Walker). *Allotopotype*, ♀, August 6, 1926. *Paratopotypes*, 5 ♂ ♀, August 6–8, 1926. *Paratype*, ♂ Jaraguà, Sànta Catharinà, Brazil, August 29, 1929 (F. Schade).

Type to be preserved in the Museum of Zoology, University of Michigan.

Limonia (*Geranomyia*) *walkeri* is named in honor of the collector, Mr. Fred W. Walker, who has collected numerous Tipulidæ in Colombia. The species is very distinct from all described forms in the single very long spine on the rostral prolongation of the ventral dististyle.

Orimarga Osten Sacken.

Orimarga bahiana sp. n.

Generally similar to *O. punctipennis* Alexander (British Guiana), differing especially in the details of venation.

Female.—Length about 7 mm.; wing, 5.6 mm.

Head light silvery gray. Mesonotal praescutum dull gray with four poorly defined grayish brown stripes; scutal lobes with two similarly colored areas. Legs pale yellow. Wings brownish yellow, the outer ends of the radial cells darker; small but conspicuous brown spots at origin of *Rs*, fork of *Sc*, tip of R_{1+2} and R_2; on anterior cord, *m-cu* and at fork of M_{3+4}; veins chiefly pale, darker in the infuscated areas Venation: R_2 shorter than R_{1+2}, straight, not angulated and spurred as in *punctipennis;* basal section of R_5 long and conspicuously arcuated, not short and straight as in *punctipennis*. Abdomen brownish black.

HABITAT: Brazil. *Holotype*, ♀, Bahia, May 1929 (R. C. Shannon).

Diotrepha Osten Sacken.

Diotrepha myersiana sp. n.

Generally similar and closely allied to *D. fumicosta* Alexander, differing especially in the venation.

Female.—Length about 6 mm.; wing, 4.6 mm.

General coloration dark brown, the abdomen black, only the tergal valves of the ovipositor yellowish horn-color. Halteres black. Legs broken beyond the trochanters. Wings with a strong blackish tinge, more saturated along the costal margin. Venation: Sc_1 ending shortly before the fork of *Rs*, Sc_2 a short distance from its tip, Sc_1 alone being about equal to R_2; free tip of Sc_2 a little shorter than R_1 beyond it; R_2 a trifle longer than R_1 before it; R_{1+2} elongate, exceeding the distance between Sc_2 and R_2 and nearly as long as *Rs*.

HABITAT: British Guiana. *Holotype*, ♀, Koriabo, Barima River, May 5, 1929 (J. G. Myers).

I take great pleasure in naming this interesting *Diotrepha* in honor of my friend and colleague, Dr. John G. Myers.

Limnophila Macquart.

Limnophila kaieturana sp. n.

General coloration brownish gray; antennæ short, black throughout; mesonotal praescutum brownish gray with three dark brown stripes; halteres pale; legs chiefly darkened; wings grayish with a heavy brown pattern; cell M_1 present; *m-cu* at near one-third the length of the relatively small cell *1st* M_2.

Female.—Length about 6.5–7.5 mm.; wing, 6–7.3 mm.

Rostrum and palpi black. Antennæ black throughout, short; flagellar segments short-oval, becoming smaller outwardly. Head gray, the posterior vertex with a large dusky area on either side of the median line.

Mesonotal praescutum brownish gray with three dark brown stripes, the median stripe broad, not reaching the suture behind; lateral stripes relatively short and indistinct; no tuberculate pits; pseudosutural foveæ reduced to a blackened marginal pit; scutum brownish gray, the centers of the lobes dark brown; scutellum and postnotum gray. Pleura brownish gray. Halteres pale yellow. Legs with the coxæ brownish gray; trochanters yellowish brown; femora yellowish brown, passing into dark brown at tips; tibiæ brown, the tips narrowly dark brown; basitarsi yellowish brown, the tips and remainder of tarsi dark brown. Wings grayish, the prearcular and costal regions more yellowish gray; a heavy brown pattern, as follows: Base of cell R; origin of Rs; along cord and outer end of cell *1st* M_2; a marginal series at ends of all longitudinal veins; fork of M_{1+2}; at near midlength of cell R_4; near outer end of cell M; at near midlength of cell *2nd A* and in the axilla; veins pale, darker in the infuscated areas. Venation: Sc_1 ending opposite or just beyond fork of Rs, Sc_2 at tip; R_2 subequal to or shorter than R_{1+2}; inner ends of cells R_4, R_5 and *1st* M_2 in nearly transverse alignment; cell M_1 subequal to its petiole; cell *1st* M_2 relatively small, *m-cu* at near one-third its length.

Abdomen dark grayish brown, the valves of the ovipositor blackened.

HABITAT: British Guiana. *Holotype*, ♀, Kaietur Falls, May 26, 1929 (Miss Alice Mackie). *Paratopotype*, ♀.

I have to thank Miss Mackie and Professor Cockerell for this interesting crane-fly. The species is amply distinct from allied regional forms in the coloration of the body and wings.

Shannonomyia Alexander.

Shannonomyia austrolathræa sp. n.

General coloration gray; mesonotal praescutum with a black median vitta; legs black, the tips of the femora abruptly yellow;

wings cream-colored, with a restricted dark brown pattern; vein R_{2+3+4} shorter than the basal section of R_5.

Female.—Length about 7 mm.; wing, 7.5 mm.

Rostrum gray; palpi black. Antennæ with the scapal segments black; flagellum paler, the incisures vaguely obscure yellow; flagellar segments oval, decreasing in size outwardly. Head gray.

Mesonotal praescutum brownish gray with a single very conspicuous median black vitta that extends to the suture; posterior sclerites of mesonotum gray Pleura gray, vaguely marked with darker. Halteres pale, the knobs light yellow Legs with the coxæ pale yellow, sparsely pruinose; trochanters obscure yellow; femora black, the extreme tips abruptly yellow; remainder of legs black Wings cream-yellow, with a restricted dark brown pattern, arranged as follows: Post-arcular; origin of *Rs*; fork of *Sc*; along cord, beginning at stigma, narrowly interrupted on M_{3+4}; tips of all longitudinal veins except R_5, largest on R_3 and R_4; outer end of cell *1st* M_2; veins yellow, darker in the infuscated areas. Venation: Sc_1 ending about opposite two-thirds the length of *Rs*, Sc_2 at its tip; *Rs* long; R_{2+3+4} short to very short; cell *1st* M_2 of unusual length, as in *lathræa; m-cu* about two-thirds its length beyond the fork of *M*

Abdomen brownish black, pruinose Ovipositor with the sternal valves blackened, the tergal valves horn-yellow, gently upcurved to the acute tips

HABITAT: Bolivia. *Holotype,* ♀, Santa Cruz, February 1929 (ex Fr. Schade).

Shannonomyia austrolathræa is most closely allied to the Colombian *S. lathræa* (Alexander), differing especially in the coloration and details of venation.

Eriocera Macquart.

Eriocera flammeinota sp n.

General coloration of body black, only the mesonotal praescutum and scutum fiery orange; knobs of halteres and legs black; wings dusky at base and apex, the central portion yellow, clearest and most extensive on the cephalic portion.

Female.—Length about 23 mm.; wing, 17 mm.

Rostrum and palpi black. Antennæ brownish black throughout, 10-segmented (♀), the flagellar segments gradually decreasing in length and diameter outwardly. Head black, the vertical tubercle very shallowly notched.

Pronotum brownish black. Mesonotal praescutum and scutum fiery orange; remainder of thorax black. Halteres brownish yellow, the knobs blackened. Legs brownish black throughout. Wings dusky at

base and apex, the central portion broadly yellow, widest along the costal margin, gradually narrowing posteriorly, the band not crossing the wing, being obscured in the marginal Anal and Cubital cells; veins yellow, darker in the infuscated areas. Venation: R_2 a little shorter than R_{2+3}; cell M_1 lacking; distal section of Cu_1 short, about two-thirds *m-cu*.

Abdomen black, including the ovipositor, only the extreme tips of the valves brightened.

HABITAT: Brazil. *Holotype*, ♀, Minas Geraes, 1897, ex Fruhstorfer Coll. Type in the Deutsches Entomologisches Museum.

Eriocera flammeinota is very distinct from all regional species of the genus.

Eriocera antennata sp. n.

General coloration light brown; antennæ (♂) elongate, approximately four times the body; vertical tubercle very high; wings tinged with brown; a restricted darker brown pattern along the cord and other veins; *Rs* angulated and spurred at origin; cells R_2 and R_3 subequal at margin.

Male.—Length about 7.5 mm.; wing, 8 mm.; antenna about 30 mm.

Rostrum very reduced, brownish yellow; palpi short, dark brown. Antennæ (♂) approximately four times as long as body; basal segments obscure yellow, the outer segments passing into brown; basal four flagellar segments gradually increasing in length and slenderness, all armed with spinous setæ; remaining segments abruptly shorter. Head testaceous yellow, the vertical tubercle very developed, subequal to the basal segment of scape in length and stouter.

Mesonotum light brown, the surface very sparsely pruinose, the praescutum with scarcely indicated stripes. Pleura with the dorsal sclerites brown, the ventral ones yellow. Halteres yellow, the knobs infuscated. Legs with the coxæ and trochanters yellowish testaceous; remainder of legs broken. Wings with a faint brown tinge, sparsely variegated with darker; stigma pale brown; origin of *Rs*, cord, outer end of cell *1st* M_2, R_{1+2} and R_2, and tip of vein R_3 narrowly seamed with darker brown; veins pale, dark brown in the infuscated areas, especially along the oblique cord. Venation: *Rs* much shorter than in *macrocera*, angulated and spurred at origin; R_{2+3+4} subequal to R_{2+3}; R_3 deflected strongly cephalad at end so cell R_2 is subequal to cell R_3 at margin; veins beyond cell *1st* M_2 not longer than the cell; *m-cu* at fork of *M*.

Abdomen brownish yellow, the hypopygium dark brown; incisures appearing darker than the ground-color.

HABITAT: Colombia. *Holotype*, ♂, Sevilla. Department of Magdalena, May 17, 1926 (F. W. Walker).

Type to be preserved in the Museum of Zoology, University of Michigan.

Eriocera antennata is allied to *E. macrocera* Alexander (Brazil), differing especially in the details of venation and wing-pattern.

Elephantomyia Osten Sacken.

Elephantomyia boliviensis sp. n.

General coloration of thorax uniform yellow; head fulvous yellow, the anterior vertex and posterior orbits grayish white; halteres yellow; legs yellow, the tibial spurs lacking; wings grayish yellow, the base and costal region clearer yellow; abdominal tergites obscure yellow, with a nearly continuous brownish black median stripe.

Female.—Length (excluding rostrum) about 6.5 mm.; wing, 7.8 mm.; rostrum about 6 mm.

Rostrum nearly as long as body (in female), dark brown. Antennæ dark brown throughout, relatively long and slender. Head fulvous yellow, the narrow anterior vertex and posterior orbits grayish white.

Mesonotum and pleura uniform yellow, the surface nitidous, without markings. Halteres yellow. Legs with the coxæ and trochanters yellow; remainder of legs yellow to brownish yellow; no tibial spurs. Wings grayish yellow, the base and costal region clearer yellow; stigma oval, pale brown; veins before the cord chiefly yellowish, the outer veins passing into brown. Venation: Sc_1 ending about opposite five-sixths the length of Rs, Sc_2 at its extreme tip; branches of Rs extending parallel for nearly their total length, cell R_2 at margin thus being approximately twice as wide as cell R_3; *m-cu* at near midlength of cell *1st* M_2, about one-half longer than the distal section of Cu_1.

Abdominal tergites obscure yellow, with a conspicuous brownish black median stripe that is almost continuous, broadest in front, more narrowed and interrupted on the posterior segments; sternites more uniformly yellow.

HABITAT: Bolivia. *Holotype*, ♀, Santa Cruz, February 1929 (ex Fr. Schade).

Elephantomyia boliviensis differs from *E. clitellaria* Alexander (Chile) in the coloration of the body and wings.

Atarba Osten Sacken.

Atarba (Atarba) boliviana sp. n.

General coloration brownish yellow; antennæ (♂) elongate; flagellum dark brown, the extreme proximal ends of the basal

segments obscure yellow; pleura infuscated; wings brownish yellow, the oval stigma only slightly darkened.

Male.—Length about 4.3 mm.; wing, 5.2 mm.; antenna about 3.8 mm.

Rostrum obscure yellow; palpi brown. Antennæ (♂) elongate, only a little shorter than the body; scapal segments obscure yellow; flagellar segments dark brown, the extreme proximal ends of the basal segments pale yellow to produce a vague annulated appearance. Head dull brownish yellow.

Mesonotum shiny brownish yellow, without markings. Pleura chiefly infuscated, the ventral sternopleurite more yellowish. Halteres pale, the knobs infuscated. Legs with the coxæ and trochanters obscure yellow, the fore coxæ more infuscated; femora yellow, the extreme tips on outer face narrowly darkened; tibiæ obscure yellow, the tips and tarsi passing into dark brown. Wings brownish yellow, the costal region clearer yellow; stigma oval, scarcely apparent against the ground-color; veins pale brown. Venation: Sc_1 ending shortly beyond origin of *Rs*, Sc_2 a corresponding distance before this origin; cell *1st* M_2 closed; *m-cu* shortly beyond the fork of *M*.

Abdominal tergites yellow, the caudal margins of the segments darkened; a dark brown ring involving segments seven, eight and caudal portion of six; hypopygium yellow. Male hypopygium with the median lobe of the sternite long and narrow, gradually widened outwardly, the lateral angles produced into acute pale horns. Aedeagus unusually long and relatively slender, gradually narrowed outwardly.

HABITAT: Bolivia. *Holotype*, ♂, Santa Cruz, February 1929 (ex Fr. Schade).

Atarba boliviana is allied to *A. brunneicornis* Alexander (Colombia), differing in the details of coloration and venation.

Atarba (Atarba) stigmosa sp. n.

General coloration of mesonotum testaceous yellow, the dorso-pleural region and postnotum dark brown; antennæ black; halteres yellow, the knobs infuscated; legs yellow, the femora narrowly tipped with brown; wings tinged with yellow, the stigma and a small cloud on the anterior cord dark brown; abdominal tergites dark brown.

Female.—Length about 6 mm.; wing, 6.5 mm.

Rostrum obscure yellow; palpi black. Antennæ black throughout, the incisures between the first three or four flagellar segments insensibly paler; flagellar segments gradually decreasing in length outwardly, the last segment subequal to the penultimate. Head obscure yellowish testaceous, vaguely marked with darker.

Mesonotum shiny testaceous yellow, without markings, the postnotum dark brown. Pleura obscure yellow, with a conspicuous dark

brown dorsal stripe extending from the cervical region to the postnotum. Halteres yellow, the knobs infuscated. Legs with the coxæ and trochanters yellow; femora yellow, the tips narrowly but conspicuously infuscated; tibiæ and tarsi obscure yellow, the tips of the latter narrowly blackened. Wings tinged with yellow, clearer in the prearcular, costal and cubital regions; stigma large, dark brown, conspicuous; a restricted brown cloud on the anterior cord; veins light brown, slightly paler in the flavous areas. Venation: Sc_1 ending opposite the origin of *Rs*, Sc_2 a short distance from its tip; *Rs* short, strongly arcuated; *m-cu* at near one-third the length of the lower face of cell *1st* M_2.

Abdominal tergites dark brown; sternites variegated yellow and dark brown, the median region more uniformly yellow, the lateral portions of the segments at near midlength with a darkened area. Ovipositor with the genital segment testaceous yellow, the valves more horn-colored.

HABITAT: Bolivia. *Holotype*, ♀, Santa Cruz, February 1929 (ex Fr. Schade).

By my key to the American species of *Atarba* (Annals Ent. Soc. America, 19: 171; 1926), the present species runs to couplet 3, disagreeing with all remaining species in the combination of marked wings and femora with darkened tips.

Teucholabis Osten Sacken.

Teucholabis (Teucholabis) salti sp. n.

General coloration of thorax chestnut, the praescutum with three black stripes; thoracic pleura ochre-yellow with two black longitudinal stripes; halteres yellow; legs yellow, the tips of the femora, tibiæ and basitarsi blackened; wings whitish subhyaline, the stigma brown, the veins of the cord darkened; abdomen black, the segments ringed with yellow; male hypopygium with the outer dististyle a long slender rod that bears an acute lateral spine at midlength.

Male.—Length about 5.5–6 mm.; wing, 5–5.5 mm.

Female.—Length, 5–6 mm.; wing, 4.5–5 mm.

Rostrum and palpi black, the former about as long as the remainder of head. Antennæ black throughout. Head gray, more ochreous beneath.

Pronotum yellow. Mesonotal praescutum chestnut, with three conspicuous black stripes, the lateral stripes delimiting the ground-color, the humeral and lateral margins broadly light yellow; median stripe more or less constricted and sometimes paler behind midlength, not reaching the suture; scutum chiefly chestnut, the lobes margined laterally with black, the median region, together with the adjacent

postero-median region of praescutum yellow; scutellum light yellow; postnotal mediotergite chestnut, the cephalic portion narrowly blackened. Pleura ochre-yellow with two black longitudinal stripes, the more dorsal extending from above the fore coxæ, including the anepisternum, dorsal pteropleurite and pleurotergite; ventral stripe including the fore coxæ, the ventral sternopleurite and meron. Halteres yellow, the knobs brighter. Legs with the coxæ black, more or less pruinose; trochanters brown; femora, tibiæ and basitarsi yellow, the tips broadly black; remainder of tarsi black. Wings whitish subhyaline, the oval stigma brown; veins brownish yellow to yellow, those comprising the cord dark brown. Venation: *Sc* long, Sc_1 ending opposite midlength of *Rs*, Sc_2 some distance from its tip, Sc_1 alone exceeding one-third the length of *Rs*; R_2 longer than R_{1+2}, in alignment with *r-m*; *m* arcuated, much longer than the basal section of M_3.

Abdominal segments black, the caudal margins conspicuously ringed with yellow; hypopygium black. Sternal pocket of sixth segment of male well-developed. Male hypopygium with the apex of basistyle produced into a short black spine, the base on mesal face with abundant delicate setulæ. Outer dististyle a long slender rod, at apex narrowed into an acute spine; at midlength with an acute lateral spine. Inner dististyle blackened, the apex bispinous, the spinous points separated by a rounded notch.

HABITAT: Colombia. *Holotype*, ♂, Rio Frio, Magdalena, December 3, 1927 (G. Salt). *Allotopotype*, ♀, July 8, 1927 (G. Salt). *Paratopotypes*, 7 ♂ ♀, July 21–December 3, 1927 (G. Salt), 25 ♂ ♀, February 18–May 26, 1925 (F. W. Walker), 2 ♂ ♂, November 12, 1925 (F. W. Walker). *Paratypes*, 100 ♂ ♀, Sevilla, Magdalena, November 19, 1925–June 8, 1926 (F. W. Walker); 1 ♂, Orihueca, November 13, 1925 (F. W. Walker). Type in author's collection, majority of paratypes in the Museum of Zoology, University of Michigan.

I take great pleasure in dedicating this interesting *Teucholabis* to Dr. George Salt, to whom I am indebted for several Neotropical Tipulidæ. By my key to the Neotropical species of *Teucholabis* (Trans. Amer. Ent. Soc., 40: 235–239; 1914), the present species runs to couplet 27, disagreeing with both included species in the diagnostic features listed above.

Erioptera Meigen.

Erioptera (Empeda) boliviana sp. n.

General coloration grayish brown; antennæ brownish black throughout; knobs of halteres infuscated; legs brownish black; wings strongly tinged with gray; Sc_1 and R_3 unusually long;

cell *1st* M_2 open; male hypopygium with the outer dististyle elongate, very unequally bifid by a small lateral branch; gonapophyses appearing as broad flattened plates.

Male.—Length about 2.8 mm.; wing, 3.6 mm.

Female.—Length about 3.8 mm.; wing, 4.4 mm.

Rostrum and palpi dark brown. Antennæ brownish black throughout; flagellar segments oval. Head brownish gray, the anterior vertex and narrow posterior orbits silvery-gray.

Mesonotum dark grayish brown, the pleura more pruinose. Halteres pale, the knobs infuscated. Legs with the coxæ and trochanters pale yellow; remainder of legs brown, covered by still darker hairs, the outer segments black. Wings with a strong grayish suffusion, the oval stigma more brownish gray; veins brown, the macrotrichia brownish black. Macrotrichia relatively long and conspicuous. Venation: Sc_1 ending about opposite one-fourth the length of *Rs*, Sc_2 exactly opposite this origin, Sc_1 thus being of unusual length; R_2 a little shorter than R_{2+3+4}; vein and cell R_3 of unusual length, both exceeding the petiole of the cell; cell *1st* M_2 open; *m-cu* close to fork of *M*.

Abdomen dark brown, the sternites somewhat more yellowish brown. Male hypopygium relatively small. Outer dististyle elongate, with a very reduced lateral branch. Inner dististyle short and straight Gonapophyses appearing as broad flattened plates.

HABITAT: Bolivia. *Holotype*, ♂, Santa Cruz, February 1929 (ex Fr. Schade).

Erioptera (*Empeda*) *boliviana* is very distinct from the remaining Neotropical species, none of which has been taken from farther south than Central America.

THE GROWTH AND DEVELOPMENT OF EPHESTIA KUEHNIELLA ZELLER (LEPIDOPTERA) AND TRIBOLIUM CONFUSUM DUVAL (COLEOPTERA) UNDER CONTROLLED CONDITIONS OF TEMPERATURE AND RELATIVE HUMIDITY.*

TOM A. BRINDLEY,
Iowa State College, Ames, Iowa

INTRODUCTION.

The confused flour beetle (*Tribolium confusum* Duval) and the Mediterranean flour moth (*Ephestia kuehniella* Zeller) have long been recorded as serious pests of stored grain products (Riley 1889, Chittenden 1896). In recent years they have served as very valuable material for laboratory experiments on insect nutrition (Chapman 1924, Richardson 1926). In spite of the economic and scientific importance of these two insects the writer could find little detailed information on their growth and development under carefully controlled conditions of temperature and relative humidity, on a normal whole wheat diet.

The writer wishes to express his gratitude to Dr. C. H. Richardson, under whose direction the work was done, for his kindly aid and helpful criticism.

METHODS OF PROCEDURE.

All the experiments carried out in this study were made under controlled conditions of temperature and relative humidity. A temperature of approximately 30° C. (Actually 29.7° ± 0.1° C. by a standard thermometer) and a relative humidity of 73% were used.

The humidity within the box was maintained between 60% and 70% by pans filled with a saturated solution of sodium chloride placed directly in front of the air currents from an electric fan. Flour under these conditions contains approximately 11.5% of moisture (Bailey 1920). All detailed studies

*Contribution of the Zoology and Entomology Department of Iowa State College.

were made in battery jar humidity chambers containing saturated sodium chloride solutions to insure a constant humidity of 73%. These jars were aerated at least once daily.

The light within the box was practically the same as that of the laboratory room.

Larvæ of *Ephestia kuehniella* for experimental purposes were reared in wide mouthed bottles 70 mm. high and 20 mm. wide at the base. The bottles were stoppered with cotton. Twenty larvæ were placed on approximately five grams of flour to guard against disease and to prevent abnormal development due to over crowding. Stock cultures of *Tribolium confusum* were maintained in battery jars 25 cm. high and 15 cm. wide.

PART I. **Ephestia kuehniella.**

THE ADULT OF *Ephestia kuehniella.*

Under laboratory conditions the emergence of the moths was not confined to any particular time of day. Newly emerged moths were observed in the cultures at all times. After emergence the female remains quiet with the tip of her abdomen raised well above the level of her body with her ovipositor protruding two to four millimeters. Virgin females have been observed to remain in this position until they were about to die.

Under normal conditions both sexes remain quiet during the day. Copulation takes place after midnight on the day of emergence. The moths separate the following morning. The length of the union was found to vary from four to six hours on ten pairs studied. Several pairs were observed to remain united for a longer time than this but in these cases both sexes died without separating.

The adults of this species are rather short lived. The average length of life for fifty pairs known to have mated was 6 days for the females and 7 days for the males. The maximum was 10 days for the females and 11 for the males, the minimum was 3 days for both sexes. Unfertilized moths were found to live somewhat longer. The average for 20 males was 11 days and for 20 females 10 days. The maximum length of life for both sexes was 15 days, the minimum 6 days.

The average weight for the adults reared under the conditions used in this study was 11.5 mg. for the males and 15.7 mg. for the females. Table I gives a summary of the adult weights.

TABLE I.

WEIGHT OF THE ADULTS OF *Ephestia kuehniella.*

NUMBER WEIGHED	WEIGHT OF EACH SEX		
		Males	Females
150 of each sex	Minimum	10.4 mg.	12.2 mg.
	Maximum	12 7	17.9
	Average	11 5	15.7
	Standard Deviation	0.6 mg.	1.5 mg.

OVIPOSITION.

Under natural conditions egg laying begins the night following mating. Twenty-five mated females kept in the dark began to oviposit in from six to nine hours. The eggs are laid singly or in masses scattered irregularly over the surface on which they are laid. The number laid by fifty pairs known to have copulated ranged from 25 to 352 with an average of 167. Table II shows the average laid per day.

TABLE II.

AVERAGE NUMBER OF EGGS LAID PER DAY BY 50 *Ephestia kuehniella.*

DAY	1st	2nd	3rd	4th	5th	6th	7th	8th
Number of Eggs..........	64	50	21	15	7	2	3	3

Twelve females from the fifty known to have copulated did not lay fertile eggs. In these cases oviposition did not begin at once but was delayed from five to six days. The number of eggs laid by these moths varied from none up to as high as a hundred for each individual.

Moths reared at 30° C. and 73% relative humidity showed a marked degree of sterility. Whether this sterility was due to

the temperature or the humidity or some other factor was not determined. Measurements in length of the moths showed them to be normal when compared with those reared under fluctuating room conditions.

The egg of *Ephestia kuehniella* is elongate oval in form. When first laid they are pearly white and slightly iridescent. Just before hatching the egg turns light yellow in color due to the development of the embryo which can be seen through the shell of the egg at this time. In length it measures on the average 0.58 mm. and in width 0.33 mm. Table III shows the size of the egg.

TABLE III.

THE SIZE OF THE EGGS OF *Ephestia kuehniella*.

No. of Eggs Measured	Size	Length	Width
50	Minimum	0 53 mm.	0 28 mm.
	Maximum	.64	.37
	Average	.58	33
	Standard Deviation	0 02 mm.	0 02 mm.

The mean weight of a single egg from fifteen group weighings of one hundred eggs each was 0.023 mg. Table IV gives the weights of fifteen hundred eggs.

TABLE IV.

THE WEIGHT OF THE EGGS OF *Ephestia kuehniella*.

Number of Eggs Weighed	Weight of a Single Egg			
	Minimum	Maximum	Average	Standard Deviation
1,500	0 021 mg.	0 025 mg.	0.023 mg.	0.005 mg.

The eggs hatch in ninety-six hours at 30° C. and 73% relative humidity (Decker and Melvin 1929).

The Larva.

The larva of *Ephestia kuehniella* immediately after hatching averages 0.866 mm. in length and averages 0.199 mm. in width across the head capsule. At this time they weigh 0.018 mg. The newly emerged larvæ are cream colored and sparsely covered with long hairs. In general appearance they remain the same throughout their development except for a slight variation in color before and after each molt. At this time the color varies from a flesh color immediately after molting to a yellowish white just before a molt. Table V gives the weight, length, and head capsule measurements by instars.

TABLE V.

The Weight, Length, and Head Capsule Width of *Ephestia kuehniella*.

Instar	Age	Head Capsule Width*		Length†		Weight‡	
		Average	Standard Deviation	Average	Standard Deviation		
1	0 days	0.199mm.	0.013 mm.	0.87mm.	0.09 mm.	0.018 mg.	(50)
1	4 days	.199	.013	1.55	.15	.040	(40)
2	8 days	.266	.016	2.38	.18	.200	(35)
3	12 days	.340	.018	4.16	.29	1.03	(25)
4	16 days	.577	.035	6.3	.50	3.14	(10)
5	20 days	.821	.030	8.5	.43	8.40	(10)
6	24 days	1.110	.032	12.6	.78	27.80	(10)

*100 individuals used.
† 25 individuals used.
‡Number weighed indicated in parentheses.

The measurements in this table were made just preceding a molt and therefore represent the maximum size attained during the instar represented.

After the larva has reached maturity it crawls to the surface of the material within which it has been feeding and spins a cocoon of silk intermingled with particles of meal and flour within which it pupates.

The Pupa.

Immediately after pupation the pupa is of a pale green color. This soon changes into a reddish brown on the dorsal side of the thorax and shades into a brownish yellow on the ventral surface. The average length of the pupa is 9 mm. and the average width in the thoracic region is 2.21 mm. Table VI shows the size of the pupa.

TABLE VI.

Size of the Pupa of *Ephestia kuehniella*.

Number of Pupa Measured	Size	Length	Width
25	Minimum	8 5 mm.	2.04 mm.
	Maximum	10 0	2.29
	Average	9 0	2 21
	Standard Deviation	0 51 mm.	0 08 mm.

The Life Cycle.

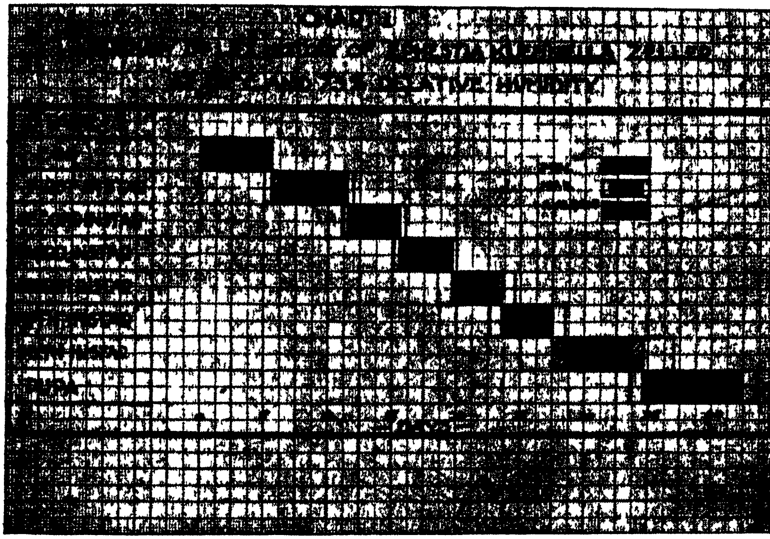
The following determinations on the life cycle of *Ephestia kuehniella* were made on one hundred individuals reared from the egg to the adult stage.

The Egg.—The hatching period of the egg was determined by placing eggs, the age of which was known within two hours, in a shell vial 60 mm. high and 12 mm. wide. This vial was then placed in a larger one 76 mm. high and 16 mm. wide which was filled to a depth of approximately 15 mm. with a saturated solution of sodium chloride[1]. The larger of the two vials were stoppered with corks. These humidity tubes were aerated daily in order to insure a fresh supply of air. When the approximate hatching day was reached the eggs were examined every two hours until the last larvæ had hatched. The average time for the eggs to hatch under these conditions was 96 hours, (Decker and Melvin, 1929).

The Larva.—The newly hatched larvæ were placed on a small amount of finely-ground whole wheat flour in a shell vial 60 mm. high and 20 mm. wide. These vials were placed in a large battery jar partially filled with a saturated solution of sodium chloride. These jars were equipped with close-fitting

tops in order to maintain the proper humidity. With this technique the larvæ could be kept, with the exception of very short periods each day during which they were examined, under very close conditions of temperature and relative humidity.

Each larva was examined daily in order to determine the number and the length of the instars. The larvæ of this species proved somewhat difficult to handle due to its habit of spinning a tube of silk about it as it feeds. This habit made it necessary to carefully remove the larva from its feeding tube



with dissecting needles for each examination. These examinations appeared to have little effect upon the length of the life cycle of this species. The total length of the life cycle of those larvæ which were examined daily was one day less than the length of the life cycle of those which remained undisturbed

Under these conditions the larva of *Ephestia kuehniella* was found to have five molts up to the time of pupation. The total length of the life cycle from the laying of the egg to the emergence of the adult was found to be 41 days with a standard deviation of 2.4 days.

The Pupa.—Reared under the conditions described above the average length of the pupal stage was 8 days. Chart 1 and Table VII give a summary of the length of the various stages in the development of this species

TABLE VII.

TABLE SHOWING THE LENGTH OF THE STADIA OF *Ephestia kuehniella*.

STAGE	LENGTH OF THE STAGES*			
	Minimum	Maximum	Average	Standard Deviation
Egg	4 days	4 days	4 days	0.00 days
1st Instar	5	7	6	78
2nd Instar	3	5	4	28
3rd Instar	4	5	4	22
4th Instar	3	6	4	33
5th Instar	4	6	4	48
6th Instar	5	12	7	1 50
Pupa	7	10	8	70

*All figures are from daily observations on 100 individuals.

TABLE VIII.

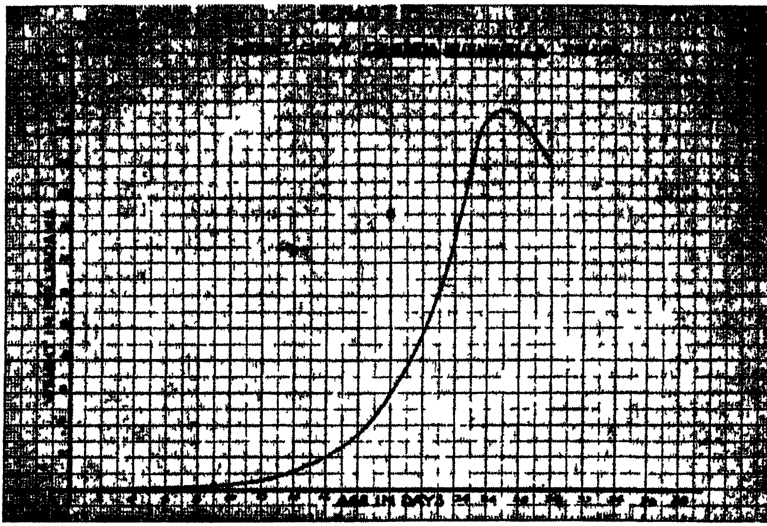
SUMMARY OF THE DEVELOPMENT OF *Ephestia kuehniella* BY WEIGHT.

AGE OF LARVAE	NUMBER WEIGHED†	AVERAGE WEIGHT	STANDARD DEVIATION
0 days	400	0 018 mg.	0 002 mg
3	160	045	016
6	140	087	009
9	100	.185	027
12	100	560	087
15	60	1.420	270
18	40	3.345	330
21	40	7 437	1 38
24	40	15 050	2 99
27	40	23 762	2 52
30	40	20 485	2 25

†These figures indicate the number weighed in four group weighings.

Weight Study.

The development of *Ephestia kuehniella* by weight was followed by making careful weighings at three day intervals during the entire period of larval development. Table VIII gives a summary of the number of larvæ weighed, their age, and their average weight.



The larvæ used in this study were reared in wide mouthed bottles previously described They were removed from their silken feeding tubes by means of two dissecting needles and were brushed free of flour dust before being weighed The weights taken were made on groups varying from one hundred of the newly hatched larvæ to ten of the more fully developed individuals Chart 3 shows graphically the actual weight increase. This "S" shaped curve resembles those plotted by Yagi (1926) in his study of the growth curves of *Bombyx mori* and *Dixippus morosus*, and those of Herms (1907) on *Lucilia caesar* and *Sarcophaga sarraceniæ*.

PART II. **Tribolium confusum** Duval.

THE ADULT.

The adults of *Tribolium confusum* are small reddish brown beetles measuring on the average 3.4 mm. in length and 1.02 mm. in width through the thoracic region.

TABLE IX.

SIZE OF THE ADULTS OF *Tribolium confusum.*

NUMBER OF BEETLES	SIZE	LENGTH	WIDTH
50 of each sex	Minimum	3 15 mm.	0 85 mm.
	Maximum	3 83	1 11
	Average	3 40	1 02
	Standard Deviation	0 14 mm.	0 05 mm.

Immediately after emergence the average weight for the males was 1.48 mg. and for the females 1.78 mg. A summary of these weights is given in Table X.

TABLE X.

WEIGHT OF THE ADULTS OF *Tribolium confusum.*

NUMBER OF BEETLES	WEIGHT	MALES	FEMALES
80 of each sex	Minimum	1 40 mg	1 74 mg.
	Maximum	1 55	1 88
	Average	1 48	1 78
	Standard Deviation	0 06 mg.	0 06 mg.

The beetles mate soon after emergence and begin to lay almost at once. Out of twenty pairs mated eleven laid fertile eggs the following day and the remainder were all laying by the end of the fifth day. A study of the exact number of eggs laid is very difficult because they are not easily located in the finely ground flour. Ten pairs of newly emerged adults

were placed on a small amount of flour in shell vials 60 mm. high and 20 mm. wide in order to obtain an indication of the number of eggs laid by the number of larvæ produced. The pairs were placed on a fresh quantity of flour each day after which the flour from which the beetles had been removed was incubated ten days. At the end of this period the larvæ were removed and counted. It was found necessary to place the adults on a fresh quantity of flour each day because of their cannibalistic nature. The number of living larvæ at the end of ten days for a ten day period is summarized in Table XI.

TABLE XI.

Number of Larvae Reared per Day from the Eggs of *Tribolium confusum*.

No. of Pairs	No. of Larvae	Day									
		1	2	3	4	5	6	7	8	9	10
10	Minimum	5	8	8	9	10	4	10	8	9	9
	Maximum	13	16	14	12	12	15	18	18	16	18
	Average	9	10	11	13	10	11	13	14	13	14

These figures are somewhat higher than those offered by Chapman (1918). The lower figures of Chapman were no doubt due to the destruction of eggs and young larvæ by the adult beetles.

The duration of the egg laying period has not been determined, but pairs in breeding jars were still laying fertile eggs at the end of six months.

The sex of the beetles used in this study was determined during the pupal stage by specific characters on the genital segment (Chapman 1918). It was impossible to find any character by which the beetles could be separated during the adult stage. The sex ratio from a study of 500 individuals was 46% males and 54% females.

The adults of this species are long lived. Out of 40 unmated beetles reared from pupæ, only one female had died at the end of 34 weeks. The newly emerged beetles are very resistant to starvation. Twenty beetles reared from pupæ lived 12 days without any food except their dried pupal skins.

THE EGG.

For experimental purposes the eggs of this species were obtained by placing several hundred adult beetles on a quantity of flour, that could be sifted through a 5XX bolting cloth.

TABLE XII.

SIZE OF THE EGGS OF *Tribolium confusum.*

NUMBER OF EGGS	SIZE	LENGTH	WIDTH
25	Minimum	0 62 mm.	0 38 mm.
	Maximum	73	47
	Average	64	40
	Standard Deviation	0 04 mm.	0 02 mm.

At the end of twenty-four hours the beetles were sifted off with a wire screen (32 mesh per inch) after which the eggs were sifted off with the 5XX bolting cloth. When first laid the eggs are white in color and are covered with a sticky substance that causes particles of flour to adhere to them. This covering

TABLE XIII.

LARVAL MEASUREMENTS OF *Tribolium confusum.*

INSTAR	AGE IN DAYS	LENGTH*		HEAD CAPSULE WIDTH†		WEIGHT‡	
		Average	Standard Deviation	Average	Standard Deviation		
1	0	1.18 mm.	0.05 mm.	0.18 mm.	0.01 mm.	0.028 mg.	(100)
2	3	1.64	.11	.22	.03	.035	(75)
3	6	2.38	.08	.29	.01	.119	(50)
4	9	3.23	.20	.40	.01	.332	(35)
5	12	4.00	.44	.53	.04	1.09	(20)
6	15	6.00	.70	.69	.03	2.40	(20)

* 50 individuals used.
†100 individuals used.
‡Number weighed indicated in parentheses.

of flour makes exact measurements of the eggs difficult. Eggs brushed as free from flour as possible measured 0.64 mm. in length and 0.40 mm. in width.

THE LARVA.

The newly hatched larvæ of this species measure 1.18 mm. in length and 0.18 mm. in width across the head capsule. At this time the newly hatched individuals weigh 0.028 mg. They are white in color and remain so until their first molt after which they become a pale yellow in color. Table XIII gives the length, weight, and head capsule measurements for this species.

The larva reaches maturity at the end of about eighteen days and then pupates in the material on which it has been feeding.

THE PUPA.

Immediately after pupation the pupa is white in color. This color is retained through half of the pupal period after which the pupa turns a pale yellow finally becomes almost brown just before emergence of the adult. The pupa measures 3.46 mm. in length and 1.12 mm. in width across the dorsal surface of the head. There is a slight difference in the size of the two sexes. The average for the males is 3.47 mm. for the length and 1.11 mm. for the width. The females average 3.74 mm. for the length and 1.11 mm. for the width.

TABLE XIV.

PUPAL MEASUREMENTS FOR *Tribolium confusum*.

NUMBER MEASURED	SIZE	LENGTH	WIDTH
25 of each sex	Minimum	3 23 mm	1 02 mm.
	Maximum	4 25	1 19
	Average	3 46	1 12
	Standard Deviation	0 23 mm.	0 56 mm

THE LIFE CYCLE.

The technique used in working out the life cycle of *Tribolium confusum* was much the same as that used in the studies on *Ephestia kuehniella*. The following data are the result of

observations and measurements made during the life cycle of one hundred beetles reared from the egg to the adult stage.

The Egg.—With the technique described for *Ephestia* the incubation period of the eggs was found to be 5.5 days.

The Larva.—The larvæ of this species were reared under the same conditions and with the same technique as described for *Ephestia kuehniella*. The individual larvæ could easily be obtained for examination by pouring the grain containing

TABLE XV.

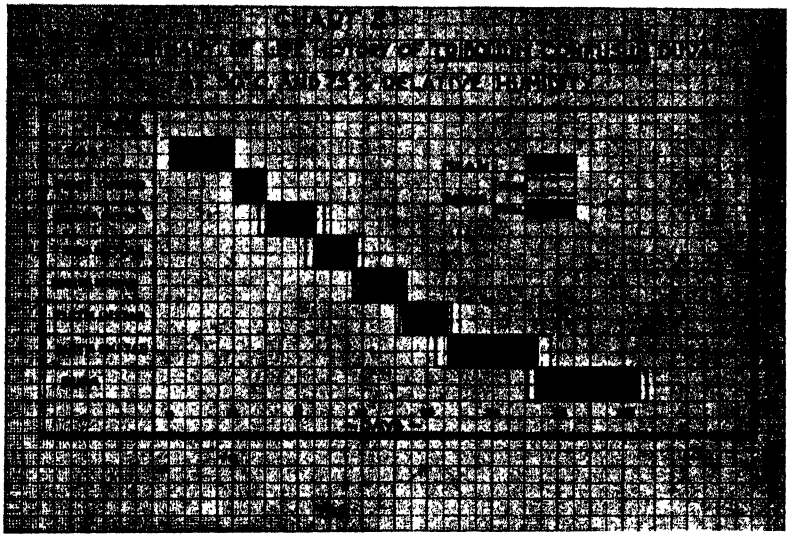
LENGTH OF THE STADIA OF *Tribolium confusum*.

STAGE	LENGTH OF STAGES*			
	Minimum	Maximum	Average	Standard Deviation
Egg	5.5 days	5.5 days	5.5 days	0 00 days
1st Instar	2	2	2	00
2nd Instar	2	3	3	05
3rd Instar	2	3	2 5	68
4th Instar	2	3	2 7	55
5th Instar	2	3	2 8	36
6th Instar	5	7	5 5	71
Pupa	6	7	6 2	44

*All figures are from daily observations on 100 individuals.

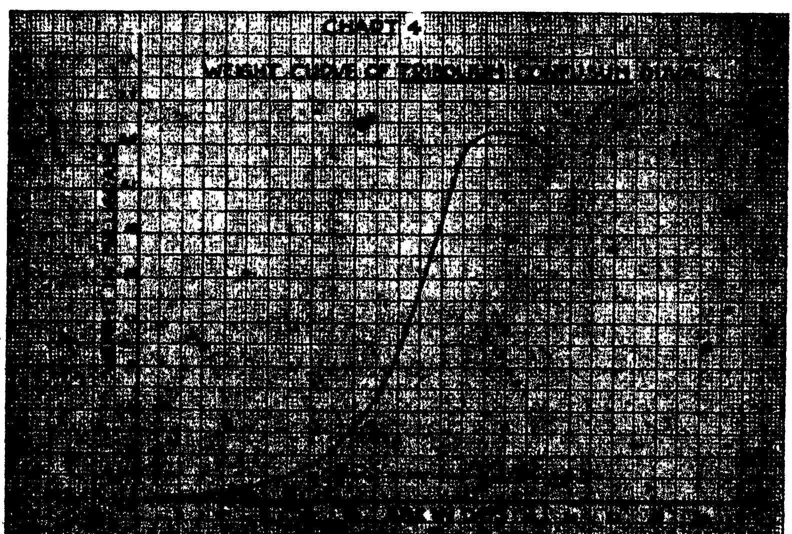
them upon a piece of paper. The larvæ will usually remain fast to the paper allowing the grain to be poured away from them. The length of the life cycle of this insect was little influenced by the handling they received. No difference could be noted in the emergence time of the insects which were handled and those which were not. Emergence studies on 425 individuals showed a maximum variation of five days for their emergence time. With this technique the larvæ were found to have five molts up to the time of pupation. The average length of the life cycle was 29 days.

The Pupa.—Under the conditions described above the average length of the pupal stage was 6 days. Table XV and Chart 2 give a summary of the length of the various stages in the development of this species.



WEIGHT STUDY.

The development of *Tribolium confusum* was followed by making careful weighings at three day intervals up to the fifteenth day of the larval period after which daily weighings were made. Table XVI and Chart 4 give a summary of the development of this insect by weight.



The larvæ used in this study were reared in wide mouthed bottles 70 mm. high and 20 mm. wide at the base. Each larva was carefully brushed free from flour before being weighed. The caterpillars were weighed in groups varying from 100 of the newly hatched larvæ to 20 of the nearly mature individuals.

TABLE XVI.

DEVELOPMENT OF *Tribolium confusum* BY WEIGHT.

AGE OF LARVAE	NO. OF LARVAE*	WEIGHT	
		Average	Standard Deviation
0 days	400	0 028 mg.	0 006 mg.
3	300	0 035	002
6	200	119	06
9	140	330	02
12	80	1 09	07
15	80	2 40	07
16	80	2 44	07
17	80	2 44	07
18	80	2 42	02

*These figures indicate the number weighed in four group weighings.

SUMMARY.

1. The growth and development of *Tribolium confusum* and *Ephestia kuehniella* was followed in four ways:
   (a) By a detailed study of the length of each instar,
   (b) By weights made at three-day periods during the period of larval development,
   (c) By measurements of the length of the larvae near the end of each instar, and
   (d) By head capsule measurements of each instar.

2. The life history of 100 individuals of each species was determined under controlled conditions of 73% relative humidity and a temperature of 30° C. Under these conditions the larva of *Ephestia kuehniella* was found to have five molts up to the time of pupation. The length of each stadium in days is as

follows: egg, 4; 1st instar, 6; 2nd instar, 4; 3rd instar, 4; 4th instar, 4; 5th instar, 4; 6th instar, 7; pupa, 8. The larva of *Tribolium confusum* also passed through five molts up to the time of pupation. The average length of the stadia was: egg, 5.5; 1st instar, 2; 2nd instar, 3; 3rd instar, 3; 4th instar, 3; 5th instar, 3; 6th instar, 6; pupa, 6.

3. Emergence studies showed the average length of the life cycle of *Ephestia kuehniella* to be 41 days with the emergence scatter covering a period of 16 days. The average length of the life cycle of *Tribolium confusum* was 29 days with the actual emergence scatter covering a period of five days.

4. In weight *Ephestia kuehniella* was found to increase from 0.018 mg. at hatching to 23.7 mg. at the end of the period of larval growth. *Tribolium confusum* increased from 0.028 mg. at hatching to 2.42 mg. at the end of the larval growth period. Adult females of *Ephestia kuehniella* weighed 15.7 mg.; adult males 11.5 mg. Adult males of *Tribolium confusum* weighed 1.48 mg.; adult females 1.78 mg.

5. The length of the two species taken by instars showed an increase from 0.87 mm. to 12.6 mm. for *Ephestia kuehniella* and an increase from 1.18 mm. to 6.00 mm. for *Tribolium confusum.*

6. *Ephestia kuehniella* was found to lay on the average of 187 eggs over a period of eight days. *Tribolium confusum* averaged ten eggs per day but the length of the oviposition period was not determined.

LITERATURE CITED.

Bailey, C. H. 1920. The hygroscopic moisture of flour when exposed to atmospheres of different relative humidity. Jour. of Industrial and Engineering Chem. IV: 1102–1103. 1920.

Decker, G. C. and Melvin, Roy. Unpublished data.

Chapman, R. N. 1918. The confused flour beetle (Tribolium confusum Duval). Minn. State Ent. Rpt. 17: 73–94. 1918.

1924. Nutritional studies on the confused flour beetle, (Tribolium confusum Duval). Jour. Gen. Physiol. 6: 565–585. 1924.

Chittenden, F. H. 1897. Some insects injurious to stored grain. U. S. Dept. Agr., Farmers' Bul. 45: 11–12. 1897.

Herms, W. B. 1907. An ecological and experimental study of Sarcophagidae with beach lake debris. Jour. Exp. Zool. IV: 45–83. 1907.

Richardson, C. H. 1926. A physiological study of the growth of the Mediterranean flour moth (Ephestia kuehniella Zeller). Jour. Agr. Research, XXXII: 895–929. 1926.

Riley, C. V. 1890. The so-called Mediterranean flour moth. Insect Life. II: 166–170. 1890.

Yagi, N. 1926. Analysis of the growth curves of insect larvae. Kyoto Imperial Univ. College of Agr. Memoirs. 1: 1–35. 1926.

HOST SELECTION AND CANNIBALISM IN THE BED BUG CIMEX LECTULARIUS L.

EZEKIEL RIVNAY,
Washington, D. C.

In a paper on the tropisms of the bed bug the author (1930), stated that the heat is the only stimulus which attracts the bug to its host—man. Furthermore, he found that every warm object calls forth such reactions, and that these reactions depend upon the difference between the temperature of the object and that of the immediate environment of the bed bug. If this is true, one would expect that any warm-blooded animal would equally attract this creature, and that it would readily feed upon any host without discrimination. The discussions in the literature dealing with this subject tend to support this view for we find long lists of animals and birds upon which the bed bugs have been found feeding. According to Martini (1923), the following hosts have been recorded: Mamalia: Bat, cat, calf, dog, guina pig, hare, mouse, rat, monkey and rabbit. Aves: Duck, goose, hen, pigeon, sparrow, starling and swallow. Several authors believe, however, that these animals or birds are attacked only in emergency—when human blood is not obtainable, and should a human being be available, the, bugs would attack man rather than animal. If this assumption is correct, the theory advanced in the beginning regarding thermotropism is false—for then one would expect that some other stimulus present in man and lacking in other animals is the alluring agent. In an attempt to throw light upon this subject the author made a study, the results of which are given herewith:

The specimens used in this study belonged to the progeny of females obtained from an old mattress, and from the cages of rodents reared in the Pharmacological laboratory of the Food, Drug and Insecticides Administration at Washington. Adult bugs were kept separately in small vials 1.5 cm. in diameter and 15 cm. long or in small test tubes 1 cm. in diameter and 10 cm. long. A piece of blotting paper was placed inside these to provide a foothold for the bugs and to reduce the

humidity. The individual bugs were labeled with Arabic numerals—e.g.: Female 3; male 9; etc. The progeny of a female, the eggs of which were laid in a period between one feeding and another, were labeled with the same numerals but an additional Roman letter was added to identify the individuals—e.g.: 20A, 20B, etc. By this labeling method it was not difficult to keep records of parentage and offspring during the course of the study. Individual records of feeding, molting, mating, egg laying, etc. were kept in most cases.

Feeding Experiments of Bugs Upon Warm Blooded Animals.

Several feeding experiments were carried on wherein bugs collected in cages of rodents, were fed upon man and those collected in infested mattresses were fed upon rodents. Similar experiments were carried on also upon the progeny of these insects and extended over a period of about four months, including the offsprings to the fourth generation. The hosts upon which they were fed were rat, guina pig, cat, rabbit, pigeon and canary. During all this time the author never observed any marked tendency showing a preference of one host over another. Seldom did any of the bugs hesitate to attack any of the animals or birds. Even those that had been fed the day before approached them quite freely. Often a meal was given to one individual from two different kinds of hosts. Thus, to quote my notes, "On June 19, nymphs 9A and 9B fed part of their meal on a cat, and completed it on a rat; both molted June 25. On June 25, larva 1B fed part of her meal on a pigeon and part on a rat; she molted June 30." In several cases, while handling these animals the hand of the author was as near to the bugs as the skin of the experiment animal, yet they seldom showed any preferenee to the hand. This was the case with all insects whether they were bugs reared on human blood or of those reared on animal blood.

Summarizing the results of all the experiments throughout this period we may say that the bed bugs show no preference in selecting the host. This is due to the fact that heat alone, and nothing else, is its guiding agent to its prey.

THE FEEDING EXPERIMENT ON COLD-BLOODED VERTEBRATES.

The question might arise: If the heat radiating from the animal is the only guiding agent of the bug to its host, how was it possible for Chatton and Blanc, (1918), to feed *Cimex lectularius L.* upon cold-blooded reptiles, such as the gecko, chameleon, *Gongylus ocellatus*, and even upon the amphibian *Rana temporaria?* Before explaining this, let us review first the experiment of those authors. Chatton and Blanc, (1918), placed a gecko in a narrow test tube so that it could not move, and also ten bugs of various ages together with it. They prepared twelve such tubes, five of which were placed in darkness at ordinary room temperatures (lot A), two were left in daylight at ordinary room temperatures (lot B) and the remaining five were placed in an incubator at 37° C. (Lot C). Half an hour later they were taken out and examined and the following were the results:

	LOT A.	LOT B.	LOT C.
Temperature................	19° C.	19° C.	37° C.
Light condition.............	Dark	Light	Dark
Number of bugs in Exp......	50	20	50
Number of bugs fed..........	24	12	37
Percentage of bugs fed.......	48%	60%	74%

These results indicate that light conditions did not effect the feeding desire of the bugs or at least did not hinder their feeding. We see also that a greater percentage of bugs fed at a high temperature than at a lower one. However, these results apparently do not agree with the thermotactic theory given at the beginning of this paper. In the first place, in the case of Lot A and Lot B, why did the bugs feed on the gecko at a temperature of 19° C. Was there a difference in the temperature of the gecko and that of the immediate environment of the bug? Then in the case with Lot C, when the temperature of the gecko was raised to 37° C., also the temperature of the immediate environment of the bugs was raised to that degree and thus there was apparently no heat current to stimulate the thermotactic reactions. In order to check the above results the author carried out the following feeding experiments:

Adult bugs, quite hungry, were placed upon the snakes, *Natrix sipedon* and *Diadophis punctatus*, but they made no

attempt to attack these reptiles, although they were left with them for some time. One of the snakes was in a glass container and quite moist and this may have caused the negative attitude of the bugs, but the other snake was in a dry box and yet no positive reactions were observed. The same procedure was carried on with the lizard, *Eumeces fasciatus*, but they did not attack it. It was evident, therefore, that reptiles at ordinary room temperature and under natural conditions do not attract the bed bugs.

I then held the lizard, *Eumeces fasciatus*, in my hand, and stretched out one of its legs against a few bed bugs. They attacked it. The same thing occurred when I placed a slightly heated forceps near one of the legs of the lizard. In these two cases the bugs did not succeed in piercing the skin of the lizard. It is clear, however, that when a reptile's temperature is raised somehow above the room temperature, the bed bugs do not hesitate to feed upon it.

The same lizard, *Eumeces fasciatus*, was used to carry on an experiment similar to that described by Chatton and Blanc. I placed it in a small vial with 5 larvæ of the third instar. Immediately upon my placing them there, they began to attack the lizard and within ten minutes four of them were feeding on the tender skin between the toes of the hind foot. After twenty minutes all four were engorged with the blood of the lizard. The fifth one made several futile attempts to pierce the skin of the lizard but without success. This feeding experiment was repeated successfully several times.

The following heat measurements explain the results obtained above:

With the aid of a thermocouple and potentiometer, I recorded the temperature in the immediate vicinity of the reptile, about 5 mm. over its back in comparison with the ordinary room temperature. Two series of measurements were made: (a) when the reptile was not enclosed in the narrow vial; and (b) when the reptile was enclosed in a narrow vial.

In the first case the difference between the room temperature and that of the immediate environment of the lizard was very small. In the latter case the difference was quite marked. When the reptile was free, a difference of 0.04 millivolts or about 1° C. was recorded. When the reptile was enclosed, its heat was preserved in the immediate environment so that a

difference of 0.13 millivolts or about 3° C. were shown above the room temperature. In his paper on the tropisms of the bed bug, the author has shown that the difference between the temperature of an object and that of the immediate environments of the bug must be at least 2° C. before any reactions may take place. Bearing this in mind we can understand why the bugs failed to attack the reptiles when they were free and did not hesitate to attack them when they were enclosed in a vial. Furthermore, the experiments show that even with reptiles heat is the only agent stimulating the bugs to feed.

Summarizing these experiments and including a few thigmotactic and hygrotactic reactions which I observed in bed bugs in their attempt to feed upon reptiles, I would say that *C. lectularius L.* under natural conditions does not attack cold-blooded vetebrates for the following reasons:

(1) The temperature of cold-blooded vetebrates varies with that of the environment and is very slightly above it. The difference between the two, however, is not sufficient to attract the attention of the bugs.

(2) The surface of reptiles is covered with scales and in addition to the physical difficulty in piercing those scales, the bugs will not attempt to do so because of the smoothness of their surface.

(3) The surface of many amphibians is moist, and the bed bugs will not attack these because of their negative hygrotaxis.

When these difficulties are removed, namely, when the heat which the reptiles give off is preserved, or their temperatures is artificially raised far beyond that of the environment; when a scaleless surface is offered to them such as between the toes or joints; and when the moisture is removed, the bugs freely feed upon these animals as the experiments of Chatton and Blanc and of the present author have shown.

Cannibalism.

A great deal has been written regarding cannibalism in *Cimex*, and while early authors believed that bed bugs did attack each other in case of emergency, when no other food is available, later authors deny this phase in the feeding habit of the bug and consider this as impossible. Quoting De Geer, (1773), we read as follows: "ce n'est sans doute pas leur unique nourriture n'ayant pas toujours occasion de se rassasier de sang

humain. Elle s'entertuent quelquefois et se sussent les unes les autres, les plus faible ou les jeunes devenant la proye des plus fortes, comme j'en ai eu l'experience sur celle que j'avais rassemble dans un poudrier." Recent authors consider this as an inaccurate observation, because they never observed it to take place.

If heat is the sole stimulant awaking the feeding appetite in the bugs, why should they not attack one of their own when the stimulus comes from that source? The present author succeeded in making one of the bugs feed upon another as follows:

A larva in the second instar was fed upon the arm of the author. It was then held carefully in a dish between the tips of a fine forceps which were slightly heated against a lamp to about 30° C. This temperature was maintained by the heat of the hand. In the dish there were 2 larvæ of the third instar recently molted and ready to feed. Attracted by the heat, the two approached the forceps and began to stroke the metal tips with the probosces. Soon they began to stroke in the same manner the body of the captive larva. The chitin of the latter was too smooth and therefore they did not attempt to pierce it. This stroking continued for several minutes because the heat conducted from the hand to the tips of the forceps exerted a continuous influence upon the two hungry insects. Finally one of the bugs happened to strike upon the membrane connecting the metasternum and the coxa of the left hind leg of the captive insect, and with a few darts pierced this membrane as well as the wall of the digestive tract. Very soon, without warning, I saw the blood being pumped from the captive bug into the tract of the attacking one. This did not continue for a long time because a movement of the captive bug forced the attacker away.

The author made several similar attempts before and also afterwards but never again did any of the bugs succeed in piercing the chitin or membrane of the captives, although in every case they continuously stroked the surface of the same.

Under natural conditions "cannibalism" may take place immediately after feeding of a bug. Then the blood which has been ingested is still warm and, no doubt, radiates heat through the body walls of the insect. Other bugs that may be in the environment of a recently fed bug may thus be stimu-

lated to attack it. A few times the author observed how hungry larvæ follow one of their own, right after it had been fed. A normal and active bug would naturally show resistance upon such attempts from the part of members of its kind. Often, however, it happens that a bug is somehow crippled after its meal. At times the digestive tract of a bug bursts during its meal or immediately after it. Upon this the ingested blood fills the coelomic cavity and hinders the activities of the creature until it finally dies. Bugs in such state may be attacked by others. A larva in this condition happened to be placed in a petri dish together with other bugs. On the following day the posterior half of the abdomen was dried and shrunken whereas the rest of it was normally soft and filled with darkened blood. The creature had been probably attacked by another bug.

In view of these observations the author is inclined to support the statement made by De Geer (1773), regarding cannibalism in bed bugs.

LITERATURE.

Chatton, E. and **Blanc, G.** 1918. Large electisme parasitaire de la punaise des lits. Son entretien aux depens des reptiles. Bull. de la Soc. d. Path. exotique 11, pp. 382–387.

De Geer, Ch. Memoires pour servir a l'histoire des Insects. Tome 111.

Galli-valerio, B. 1917. Note de Paras. et de technique paras.—Cent. Blt. Paras. u Infek. I Abt. 53, p. 177.

Girault, A. A. 1907. A Bibliography of the Bed Bug C. lectularius L. Zool. Ann. Vol. II.

1908. Notes on feeding habits of C. lectularius. Psyche, 14, pp. 85–87.

Girault, A. A., and **Strauss, J.** 1905. C. lectularius and C. columbarius. Host Relations. Psyche 12, pp. 117–123.

List, G. M. 1925. Proc. Biol. Soc. Wash. 38, No. 23, pp. 103–110.

Marlatt, C. L. 1916. The Bed Bug. U. S. D. A. Farmers' Bul. 754, pp. 1–12, figs.

Martini, E. 1923. Lehrbuch der Medizinishen Entomologie Jena; 462 pp., 244 figs.

Rivnay, E. 1930. The Tropisms of the Bed Bug, C. lectularius L. Mss.

Slingerland, M. V. 1893–94. Bats and Bed Bugs. Rural New Yorker, pp. 588–589, 718, 766, 850.

PAUROPODA FROM NORTH AMERICA.

WILLIAM A. HILTON,
Department of Zoology, Pomona College, Claremont, California.

Members of this group have been considered as representing a distinct class of Arthropoda. I am inclined to agree with this interpretation although Hansen, '01, who has done so much careful work in this field prefers to keep them as an order.

Sir John Lubbock was the first to recognize these little eighteen-legged centipede-like animals and described two species from his English collection in 1867. Packard in 1871 described a new species from Salem, Mass. Ryder in 1879 described a new species of Eurypauropus, a new genus erected by him and mentioned the two species given by Lubbock. These were found in Fairmount Park, Philadelphia. Latzel divided the group into two families and named some new forms. Schmidt in 1895 considered the anatomy and Kenyon in the same year considered internal and external structures and gave a summary of classification. In Russia, Tomosvary, 1884, in Hungary, Daday, 1889, Silvestri in Italy, 1894 and Attems 1895 in Austria, all have described new species. Haase in Germany in 1885 and Berlese and others have also done something with the group. Cook in 1896 divided the group into three orders and listed fifteen species, several of which were given as new. Three new genera were given and the genus Stylopauropus was accepted by Hansen. Perhaps the most important paper is by Hansen in 1901. The last author has the most extensive monograph in which a number of species are described from Europe and many other parts of the world. Bagnall, 1908-1918, has a number of short papers on the distribution of these animals in the British Isles, chiefly England and Harrison describes new forms from New South Wales.

So far as I know the only references to the distribution of Pauropoda in North America are the papers of Packard, Ryder and Kenyon in the eastern United States, the paper of Cook dealing with Long Island and Indiana forms and my own records from California in 1927. Williams and Hefner report them from Ohio in 1928.

I have now collected material from a number of distant localities in North America and the present paper is a partial report of the group from my collections during the past two years. Many more localities were searched than appear in these records, but conditions are not always the best when one has the opportunity to search.

In the description of the forms at hand I have tried to pick out differences that can be recognized as well as certain others that are not so striking but with the stress upon the former. With my material I find that there are many characters used by Hansen that seem to be too variable. I find also that certain characters are better for some individuals. These forms were not easy to study. I found it necessary in many cases to use caustics to clear the specimens, and by such severe methods with such delicate creatures I feel certain that no important skeletal structure escaped me. The antennæ are remarkably constant within a small group, the distribution of the long sense hairs and their general proportions are also quite uniform. There is a certain amount of variability in the smaller body setæ between the larger groups and there is a certain amount of variability in the adult length.

FAMILY PAUROPODIDÆ, LUBBOCK

Pauropodidæ, Lubbock. Trans. Linn. Soc. 26, 1867.
Ryder. Amer. Nat. 13, 1879.
Pauropoda agilia, Latzel. Verhndl. d. zool.-bot. Ges. Wien, 23, 1883.
Pauropodidæ, Bollman. Bul. U. S. Nat. Mus. 46, 1893.
Pauropodidæ, Hansen. Vid. Medd., 1901.

The body is four or more times as long as wide with the legs projecting laterally. The head and upper thoracic region are quite narrow. The head is free and uncovered above. Usually there are four rows of hairs on its upper side and often the last row is near the posterior margin of the head. The body has six terga very slightly chitinized. All but the first terga have eight hairs, according to Hansen, but I have found many variations. The five pairs of tactile setæ are inserted inside the lateral margins of the terga; the last pair is the longest. The legs have the central claw moderatly long or rather short with a proximal pad or empodium. In front of this is another claw with a pad on its lower margin. A small posterior claw may have a pad and may be very poorly developed on the last leg.

The character of the claws and the distribution of the small dorsal setæ are from Hansen, but I have found exceptions in my material.

Pauropus Lubbock.

Pauropus, Lubbock. Trans. Linn. Soc. London, 26, 1867.
Ryder. Am. Nat. 13, 1879.
Latzel. Ges. Wien, 33, 1883.
Kenyon. Tufts College Studies, 4, 1895.
Hansen. Vid. Medd., 1901.

The most easily recognized characters are in the antennæ. The joint bearing the single flagellum is usually longer than the one bearing two branches. One of the two branches last mentioned is usually shorter than the other. The globulus is never shorter and generally much longer than its stalk. According to Hansen also the sternum of the anal segment has at least two and usually three pairs of setæ. I have not always noted this.

Pauropus californianus n. sp. (Figure 1.)

Length .88 mm.; width of the head, .08 mm.; width of body, .16 mm. The head has three rows of hairs dorsally, six in the first two rows and four in the last. The eye areas are rather small. The first body segment has two rows of hairs dorsally with four in each row. The second segment is similar. The third and largest segment has six in the first row, 2 in the second and four in the third. The 4th body segment is about as large as the last with three rows of hairs dorsally and with two in each row. The 5th segment has from one to two rows of hairs with four hairs in all. The last segment has four hairs above and nine below with one much larger pair.

The plume-like sensory hairs are all .08 mm. long, but the last which is .12 mm. in length.

Ventral hairs are poorly developed but a series of spines was found between all the leg pairs but the last. Between the first legs the spine is long, curved and pointed, between the second it is conical, between the third it is small, between the 4th it is small and conical, between the fifth it is rounded, between the 6th it is truncated and between the eighth leg pair it is long and conical.

Antenna. Length, .12 mm., the base is .04 mm. long. The ramus bearing the globulus slightly shorter than the other. Longer flagellum of the globulus branch nearly as long as the flagellum of the globulus lacking ramus. The globulus is almost sessile and nearly spherical. The basal part of the antenna has a long hair, the second joint has two small hairs and the third joint two small ones while the fourth joint has a long hair.

Legs. They are nearly equal in length. Beginning with the first leg they are as follows: .08 mm.—.085 mm.—.09—.09—.085 mm.—.85—.085—.12 mm. There are five segments in each of the first and last pairs of legs. All the other legs but the first and last pairs have six segments. The claws are small. Small club-shaped hairs are found on the basal segment of all the legs. The length of the joints of the legs are as follows, beginning with the longest joint:

First leg: 5–4–3–2–1. Second leg: 6–4–3–2 (1–5). Third leg: 6–2–4–3–1–5. Fourth leg: (6–2)–(3–4)–1–5. Fifth leg: 6–2–4–3–1–5. Sixth leg: (6–2–3–4)–5–1. Seventh leg: 6–4–2–3–1–5. Eighth leg: 6–4–3–2–1–5. Ninth leg: 5–4–3–2–1.

The above description was from a male specimen which was used as the type and now in the Pomona College collection. It with others was collected in the College Park. Other specimens obtained in the same locality differ in minor details, but the distribution of the dorsal hairs and general character of the antennæ are much the same in all.

One specimen had legs of the following lengths: First leg and second .09 mm.; third and fourth, .10 mm.; fifth, .11 mm.; sixth, .10 mm.; 7th, .06 mm.; 8th, .06 mm.; ninth, .09 mm. The length of the joints also differed slightly.

Specimens obtained a mile away seemed the same species. One of these was .64 mm. in length with the head .045 mm. broad, the body at the broadest, .10 mm. The total antennal length was .08 mm. The first pair of legs was .06 mm. in length and the last .09 mm. The last tactile plume sense hair was .09 mm. in length.

Another specimen was .74 mm. in length and another some four miles away was slightly different. An adult from the South Hills near Pomona for instance was .8 mm. in length with the length of the legs as follows: First leg, .06 mm.; second, third, and fourth, .065 mm.; sixth, 7th, 8th all 10 mm.; ninth, .12 mm. In this the arrangement of the dorsal hairs was slightly different. On the head there were two rows, one with four and the posterior with six hairs. The first body segment has one row of three hairs. The third body segment has three hairs on each side instead of four. The fourth has two rows, the first of five and the second of four hairs. The fifth has two rows, the first of four hairs the second of two. The sixth has two rows, the first of four hairs and the second of two.

In all these specimens collected within a radius of four miles there are slight variations, but all agree in antennal characters, in caudal hairs as well as in general proportions, but not in size.

Among the specimens in the last locality one specimen was found with six pairs of legs. Its length was .56 mm. and with a head width of .05 mm. and body width of .01 mm.

A distinctive feature of the species is the simple anal plate.

Pauropus medius n. sp. (Figures 2 and 4.)

Length 1.28 mm. Greatest width, .16 mm.

The head has two rows of hairs of four each. The first body segment has one row of four hairs. The second body segment also has one row of four hairs. The third segment has three rows of two hairs

each. The fourth has three rows of hairs each of two hairs. The fifth segment has two rows, the first of four, the second of two hairs. The sixth has three rows of hairs with three hairs each. The eye areas occupy about one-third of the lateral margin of the head.

The first plume sensory hairs is .10 mm. in length, the second is .14 mm., the third is .16 mm. and the last is .28 mm.

Antennæ are .2 mm. in length of which the basal part is nearly half as long. The non-globar ramus of the antenna slightly longer than the ramus of the globus division. Between the basal joints of the two rami is a small globular body. One flagellum of the globular division of the antenna is shorter than the other. The globus itself is small with a very little stalk.

Legs with five joints in the first and ninth legs, but in the last legs the terminal joint is almost divided into two. Tarsal claws are moderately heavy, especially the ninth pair. There are spatulate hairs on the basal joints of upper legs but forked hairs on the two basal joints of the ninth legs.

The length of the legs is as follows:

The first is .11 mm. long; the second is .12 mm. long; the third is .13 mm. in length; the fourth and fifth are .14 mm. in length; the sixth is .16 mm.; the seventh is .14 mm.; the eighth is .18 mm.; the ninth is .28 mm. The proportions of the first leg are as follows beginning with the longest joint in each case. The joints of the first leg are: 2–5–3–1–4. The joints of the eighth leg are: 3–4–6–2–1–5. The joints of the ninth leg are: 5–4–3–2–1.

Some of the distinctive features of this species are the club-shaped hairs of the upper legs, the long ninth pair of legs, the rather large tarsal claws and the globular lobe between the two joints of the antennæ. The partial division of the last joint of the ninth legs should also be mentioned. The caudal region is not particularly distinctive at first sight, but on closer examination there are found three dorsal and three ventral setæ of moderate length and in a slight lobing on the ventral side in the middle line are two rather remarkable compound spines, the outer ramus of each one being pointed and the inner ramus truncate with a minute oval jointed tip as shown in the figure. No such structure was found in the previously described species, where the ventral plate was in no way remarkable.

This species was determined from specimens from Temiscal, California.

The type, a female, is in the Pomona College collection.

Several specimens were collected in December 3, 1927.

Pauropus santus n. sp. (Figure 5.)

Length 1.06 mm. Head width .08 mm. Widest part of the body, .16 mm. The head bears ten short hairs of which four are more medial and two pairs of three each are lateral. These hairs are banded.

The first segment of the body seems to be free of hairs above. The second body segment bears two hairs. The third body division has two rows of hairs, the first or more cephalic of four, the second of two hairs. The third and fourth segments have each two rows of two hairs. The sixth body division has three rows of two hairs each. The caudal region above shows six rather long hairs. Below the anal plate bears four rather long hairs. It is notched on each side to a moderate degree and in each notch is situated a small compound spine composed of three lobes.

The Antennæ are much as in other members of the genus with the flagellum of the non-globus-bearing branch slightly longer than the longest division of the globulus-bearing division. The shorter flagellum of this last branch is about one-half the length of the longer ramus. The globulus is small and almost without stalk. There are prominent hairs on each antennal segment and on the basal globulus segment. The eye areas are quite large. They make up about one-half the lateral margin of the head.

Several of the legs are of the following lengths:

The first leg, .08 mm.; the second leg is .10 mm. long; the eighth leg is .12 mm. in length; the last leg is .16 mm. in length. The claws are fairly prominent on the first and last legs and not quite so marked on other legs.

The hairs on the basal joints of all legs are slender and biramous on the last pair of legs.

The plume hairs of the body are all .08 mm. in length except the last and it is .12 mm. long.

The leg proportions for several legs are as follows: In each case the longest joint is mentioned first First leg, 5–(4–3–2) 1; the second leg, 6–3–4–2-1–5; the ninth leg, 5–2–3–4–1.

Specimens were collected at Santa Cruz Island, California, April, 1929.

The above description is from a female which serves as the type. In the Pomona College collection.

Pauropus indigenous n. sp. (Figure 3)

Length .69 mm.; width of the head, .07 mm.; width of the body at widest point, .12 mm.

The head has two rows of hairs with four in each row. The first body division has one row of six dorsal hairs. The second body segment has two rows of hairs dorsally with six in each row. The third body segment has two rows of hairs with six and four hairs. The fourth dorsal region has three rows of hairs with 4, 6 and 2 hairs. The fifth body segment has three rows of hairs with four hairs in each row

dorsally. The sixth dorsal segment has two rows of hairs with four in each row. The caudal region has three pairs of nearly terminal hairs, the central of the three pairs being longer. The anal plate below shows a slight undulation with two minute central hairs and a minute lateral hair on each side. There is also a more lateral larger pair which was counted in the three pairs of rather large terminal hairs.

The head has a pair of rather large plumose hairs below. The antennæ do not differ from those last described in any way.

The long plumose setæ are of the following lengths: First hair, .08 mm. long; the second hair, .12 mm. in length; the third and fourth hairs, .14 mm. in length; the fifth hair, .15 mm. long.

Legs. The first and last pairs are five-jointed, all the rest are six-jointed. There are slender hairs on the two basal joints of the upper legs and slender forked hairs on the two basal joints of the ninth leg. In length the first leg is .12 mm. long; the eighth is .17 mm. and the ninth is .16 mm. long. The leg proportions are as follows beginning with the longest joints in each leg: First leg, 2–3–4–5–1. Second leg, 6–2–3–4–1–5. Third leg, 2–6–4–3–1–5. Fourth leg, 3–4–2–6–1–5. Fifth leg, 2–6–3–4–1–5. Sixth leg, 2–3–4–6–1–5. Seventh leg, 2–3–4–6–1–5. Eighth leg, 2–3–4–6–1–5. Ninth leg, 5–(3–2–4–1). The claws of the legs are moderately developed. There is a small curved ventral spine between the second pair of legs.

Several specimens from Indian Hill, near Claremont, California. The type is a female in the Pomona College collection.

Pauropus quercus n. sp. (Figure 6.)

Length .64 mm. Proportions about as usual for the genus. Head with three rows of small hairs, the first row with six, the second row with six and the third with two hairs.

The body divisions above have the following distribution of small hairs:

First segment with two rows of four hairs each. The second segment also dorsally has two rows of hairs, the first with four, the second with six hairs. The third dorsal segment has three rows of hairs, the first with two, the second with four and the third with four hairs. The fourth dorsal division has two rows, the first with two and the second with four hairs. The fifth segment has three rows of hairs, the first with four, the second with two and the third row also with two. The sixth dorsal segment has four hairs in a row on its caudal edge, all of which are quite long.

The anal plate is not very distinctive. There are two pairs of rather long dorsal hairs and two pairs of more ventral ones. The more lateral of the ventral hairs is thicker than the others and with a thick basal joint.

The antennæ are much as in the first species described, there is no distinctive feature. Their total length is .09 mm. of which the basal joint makes up .04 mm.

The lengths of the legs are as follows:

First leg, .06 mm.; second, .06 mm.; third and fourth, .07 mm.; fifth, .08 mm.; sixth, .08 mm.; sixth, .08 mm.; seventh, .08 mm.; eighth, .08 mm.; ninth, .09 mm.

The proportions of the legs are as follows beginning with the longest joint in each case: First leg, 5–4–2–3–1. Second leg, 6–(3–2–4)–1–5. Third leg, 6–4–3–2–1–5. Fourth leg, 6–4–3–2–1–5. Fifth leg, 4–6–3–2–1–5. Sixth leg, 2–3–6–1–5. Seventh leg, 2–4–3–6–1–6. Eighth leg, 2–4–3–6–1–5 Ninth leg, 5–5–3–2–1.

The feet are as in *P. californianus* and in many respects it resembles this species, there are, however, no ventral spines as in this species.

The distinctive features of this species are in the anal region, the jointed pair of caudal hairs and the total lack of ventral hairs or spines.

Pauropus globulus n. sp. (Figure 7.)

Length .64 mm. General proportions as typical in the genus. Antennæ much as in other members of the genus but with a distinctive globular joint slightly smaller than the globulus.

The dorsal setæ are as follows:

The head has three rows of hairs; the first with four, the second with six and the third with two. The first body segment has one row of two hairs on each side or four in all. The second division of the body has one row of four hairs. The third body segment has two rows of two hairs each. The fourth segment has two rows of hairs, the more cephalic of these has four hairs, the more caudal has two hairs. The fifth dorsal body division has one row of four hairs. The sixth dorsal segment has one row of two hairs.

The anal segment was not clearly seen in any of the specimens but it seemed to be provided with two central shorter caudal hairs and two longer lateral hairs to these.

The lateral sensory setæ were as follows:

The first or more cephalic was .06 mm. in length; the second was .05 mm.; the next was .06 mm. long; the fourth was .05 mm. long and the last was .09 mm. long.

It was difficult to measure the length of legs but the proportions of the joints were as follows, beginning with the longest joint in each case: First leg, 5–4–3–2–1. Second leg, 2–4–6–3–1–5. Third leg, 2–3–4–6–1–5. Fourth leg, 6–(2–4–2)–1–5. Fifth leg, 6–(2–3)–1–5. Sixth leg, 2–6–4–3–1–5. Seventh leg, 6–4–3–2–1–5. Eighth leg, (6–4–3–2)–1–5. Ninth leg, 5–4–3–2–1.

The basal joints of the legs have slender hairs. The second joint of the ninth leg has a single hair but the first basal joint has a double hair both branches of which are slender. There is a long hair on the fourth joint of the ninth leg and this hair reaches beyond the last joint of the leg. The tarsal claws and hairs are about as usual.

Several specimens were collected at Mountain Meadows, a few miles from Claremont, and because of the use of caustics all are in bad condition. Further study may show other characters not seen in these specimens at present. Distinctive feature, the globular basal joint of the globulus. Description from a female, now an imperfect specimen in the Pomona College collection.

Pauropus pinus n. sp. (Figure 9.)

Length 1.04 mm. Head width, .08 mm. Widest part of the body is .16 mm. Antenna; length of the base, .08 mm. and .14 mm. total length. All three flagellar branches nearly equal in length. The globulus is on a short stalk with hairs on each of the basal joints. There is one very long hair on the last basal joint near the base of the globulus division of the antenna. At this point also there are two small globular bodies, one with stalk over twice as long as the globule. The other and larger globular body has a very short narrow base of attachment. Near the true globulus there appears to be a second globule about half the diameter of the true globulus. The eye area occupies about one-third of the lateral margin of the head.

The head has six dorsal hairs in from two to three rows.

Dorsally the body regions bear hairs as follows:

First body segment, four hairs in two rows of two each. The second body division has one row of three hairs. The third body segment has two rows of two hairs each. The fourth body segment has about two rows of four hairs each. The fifth segment has two rows of three and of four hairs. The sixth segment has a cephalic row of four hairs and a second row of two hairs.

The anal region has four or five rather long terminal or slightly lateral hairs with two large double spines on the anal plate. These are much as in *P. medius* but they are larger and more truncate with the lateral parts somewhat pointed. There are no terminal joints evident here.

In the type specimen and one or two others the long sensory hairs are with very little indication of a plumed condition.

The long sensory hairs are of the following lengths: The first is .10 mm. long and so are all the others but the fifth which is .28 mm. long.

On the ventral side of the body between the third to the eighth pairs of legs there is a pair of small hairs.

The basal segments of the legs have cylindrical hairs. On the two basal segments of the ninth legs there are branched hairs, each of the two branches being nearly cylindrical.

The lengths of the legs are as follows: The first pair of legs is .11 mm. The second leg pair is .15 mm. The third pair of legs is .16 mm. long. The fourth legs are .15 mm. The fifth pair is .17 mm. The sixth pair is .20 mm. long. The eighth pair is .22 mm. long. The ninth pair of legs is .24 mm. long.

The leg proportions are as follows, beginning with the longest joints in each case: First leg, 2–4–3–5–1. Second leg, 6–(4–2)–1–(3–5)–1. Third leg, 6–4–2–1–3–5. Fourth leg, 6–4–2–1–3–5. Fifth leg, 6–(4–2)–3–1–5. Sixth leg, 6–4–2–3–5–1. Seventh leg, 6–4–2–3–5–1. Eighth leg, 6–4–2–3–5–1. Ninth leg, (5–6)– 4–3–2–1.

The claws of the legs are rather large and on the last pairs of legs especially the more ventral pad or claw is very large. The tibia here also bears an unusually long hair which reaches well below the tibio-tarsal joint.

The species is especially characterized by the peculiar caudal spines, the ventral hairs and the peculiar globular bodies on the antennæ.

The specimens were collected at Big Pines, in the San Gabriel mountains at about seven thousand feet elevation, November 26, 1927.

The type, a female, is in the collection of Pomona College.

Pauropus caudaspinosus n. sp. (Figure 8.)

Length 1.42 mm. Head width, .16 mm. Broadest part of the body, .28 mm. Antennæ of the usual type with hairs on all basal joints. Globulus branch with shorter flagella than the other branch. The two branches of the globulus quite unequal in length. Total length of antenna, .13 mm. of which .06 mm. is basal portion of the usual four joints. The eyes occupy about one-half the lateral margin of the head.

Dorsally the hair distribution is as follows:

The head bears four small hairs. The first body division has a row of four hairs. The second body segment bears two rows of two hairs each. The third division bears two rows of two each and that seems to be the condition with all the other segments.

The anal region has about four terminal and lateral hairs on each side and the anal plate bears two sharp central spines and on each side of this pair is a single delicate spine or hair.

The plume hairs have lost their plume-like character in the type. The last of these is the longest and is .32 mm. long.

In the cephalic region there is a single scale-like spine of two slightly unequal blades. The basal joints of the legs bear club-shaped or blade-like spines. The last leg bears on its two basal joints a branched rather irregular spine with two rami. The spine of the second basal joint of the last leg is larger than that of the first basal joint.

The lengths of some of the legs are as follows:

First, second and third legs are .15 mm. in length. The eighth leg is .32 mm. in length and the last leg is .33 mm. long.

The proportions of a few legs are as follows:

First leg, (5–2)–(3–4–1). Second leg, 6–2–3–1–4–5. Third leg, 6–2–3–1–4–5–. The last leg has six joints in this type and the lengths are 5–4–3–2–6–1.

The description is based on a female used as a type in the collection of Pomona College.

Some of the distinctive characters are shown in the six-jointed ninth pair of legs, the club-shaped and even spatulate basal spines of many of the legs, the single ventral spine of a double nature and the four rather prominent anal spines, the two lateral being much more delicate, but all four being sharply pointed.

The specimens were collected in woodland one mile north of Waverly, New York, in August, 1928.

Pauropus mexicanus n. sp. (Figure 10.)

Length 1.56 mm. Head width, .10 mm. At the widest part the body is .20 mm. The total length of the antenna is .13 mm. and the base is .04 mm. The antenna is typical of the genus but there are several hairs and one or more small globular bodies at the base of the globulus. The flagella of the globulus branch are unequal in length as is usual. There were few hairs on the dorsal side and not easily determined in the specimen. There seem to be but few pairs for the upper segments, but the caudal region is well provided, there being about six hairs for the next to the last segment and about seven pairs of rather long caudal hairs. No peculiar features were noted in the anal region.

The lateral plume setæ are about .08 mm. in length but may be longer than this in life.

The length of the legs is as follows:

The first legs are .08 mm. in length; the second legs are .10 mm.; the third legs are .15 mm. long and the last legs are .16 mm. long.

The leg proportions of a few legs are as follows, the longest joint is mentioned first in order:

The first leg, 5–4–3–2–1. The second leg, 6–2-3–4–1–5. The last leg is 5–(4–3–2–)-1.

The hairs on the basal joints of the legs are slender. The claws are moderately prominent.

The species is based on female specimens collected fifty miles north of Mexico City. The specimens were collected in November, 1928.

What there is left of the type after study is in the Pomona College collection. It is very difficult to determine all the points of difference in these small specimens and at the same time save them for further study, because in some cases it is necessary to use caustics to clear the opaque parts of the body.

Stylopauropus Cook.

Pauropus, Lubbock. Trans. Linn. Soc. London, 26, 1867.
Latzel. Ges. Wien. 13, 1883.
Kenyon. Tufts College Studies, 4, 1895.
Stylopauropus, Cook. Brandtia, iv, 1896.
Hansen. Vid. Medd., 1901.

The stalk of the globulus is considerably longer than the transverse diameter of the globulus itself. Hansen also says that the lower antennal branch has the anterior margin considerably longer than the posterior. Its anterior flagellum is longer than the other. The sternum of the anal segment has the posterior pair of setæ only. The first of these characters is easily recognized, the others are not so easy and may be less important and possibly more variable. They seem to be less constant among the specimens of the genus about to be described.

Stylopauropus digitus n. sp. (Figure 11.)

Length 1.32 mm. Width of the head, .10 mm. The body at its broadest part is .18 mm. The total length of the antennæ is .13 mm., of which the base is .04 mm. The globulus branch of the antenna is heavier and slightly longer than the other but there is little real difference in their lengths. The globulus is on a stalk slightly longer than the diameter of the globulus. There is no marked difference in the lengths of the three flagella, but one of the pair is shorter than the others. The eye areas on the head are large and occupy most of the side of the head.

The distribution of dorsal setæ is as follows:

The head bears two rows of short plume hairs with eight hairs; four in each row.

The first body segment has one row of four hairs. The second body segment seems to be without hairs above. The third body segment has two rows; the first has two hairs; the second has four hairs. The fourth body segment has two rows of four each. The fifth has three rows of hairs; the first with two; the second row with two; the third row with four hairs. The sixth body segment has two rows; the first with two hairs and the second with three hairs.

The caudal region is bilobed, each lateral lobe bearing three more or less terminal hairs. In the middle line is a delicate rather broad projection which seems characteristic of the species.

The long sensory setæ seem to be .08 mm. long, but the next to the last in the type was .06 mm. long.

The leg lengths are as follows:

The first leg is .05 mm.; the second is .07 mm. which is also the length of the third. The fourth is .06 mm. in length. The next to the last leg is .08 mm. long and the last is .16 mm. long.

The leg proportions are as follows:

The first leg joints beginning with the longest for the first leg; 5–2–(3–4)–1; second leg, 4–2–6–3–1–5; third, 3–6–2–4–1–5; seventh, (4–2–6)–3–1–5; fifth, 4–3–2–6–1–5; sixth, 2–3–4–6–1–5; seventh, (4–2–6)–3–1–5; eighth, 4–6–3–2–1–5; ninth, (2–4–5–3)–1.

The third, fourth, sixth and the ninth legs have long claws which are especially hooked in the ninth pair of legs. The setæ on the basal joints of the legs are straight.

Several specimens collected at Laguna Beach, Orange County, California and one immature from Catalina Island with five pairs of legs may be the same species. This last specimen was .56 mm. long with a head width of .12 mm. and a body width of .16 mm. The caudal region was not the same as the Laguna Beach specimens.

The distinctive features of this species are the following: The delicate median caudal projection, the large eye areas, the plume hairs on the head and the long hooked claws of the last and a few other legs.

The type is a female in the Pomona College collection. This with several other specimens was collected one mile north of Laguna Beach, on January 6, 1929.

Stylopauropus locatus n sp. (Figure 12)

Length 1.1 mm. Proportions usual, the head width about .1 mm. and body about .16 mm. Total length of antenna .16 mm. with the length of the base .16 mm. The globulus bearing base is slightly shorter than the other. Flagella of this branch are about equal in length and much shorter than the other flagellum, in fact about half as long as the unpaired flagellum. The globulus is on a slender stalk a little longer than its diameter with small lateral hairs on each side of the globulus itself. The eye areas were not particularly noted and further specimens from the type locality will be needed to determine their real character as the specimens at hand are injured by the caustics applied for their study. However the eyes were not conspicuous in the specimens examined.

The distribution of dorsal hairs was as follows:

The head had two rows of hairs, the first row of four and the second of five hairs. The first body segment had two rows of two hairs each. The third body segment had three rows of two hairs each. The fourth segment had two rows of two hairs each. The fifth segment had two rows of hairs, the first with two hairs the second with four hairs. The last segment had two hairs on each side of the body.

The anal segment was not particularly studied as it showed no very distinctive features. There were three lateral hairs on each side with a slight bilobed ventral plate.

The lengths of the lateral sense hairs was not taken because they were evidently injured in all the specimens.

The leg lengths were as follows:

Beginning with the first and ending with the ninth leg the lengths in milimeters is given; .12, .13, .13, .14, .16, .18, .18, .18, .28.

The proportions of the legs are as follows, beginning with the longest joint in each case: First leg, 5–2–4–3–1; second leg, 6–5–2–3–4–1; third leg, 6–2–3–1–4–5; fourth, 6–2–4–3–1–5; fifth, 6–2–3–1–4–5; sixth, 6–2–3–1–4–5; seventh, 6–2–3–1–4–5; eighth, (2–5)–(4–3)–1–6; ninth, 5–4–3–2–1.

The legs have rather small claws. The hairs on the basal joints of the legs are rather irregular in distribution and form. They are short and often spatulate or club-like. On the first pair of legs a single slightly curved small hair is located on the third basal joint. In the second pair of legs a similar hair is located on the second basal joint. A smaller shorter hair is located on the second basal joint of the third pair of legs. The fourth pair of legs has a larger longer hair on the basal leg joint and a shorter spatulate hair on the second basal joint. The fifth leg has a small spine on the second basal joint. All the other legs, that is the sixth to the ninth pair have two hairs, one on each of the two basal joints. The hair on the basal joint of all of these is larger and more spatulate than the second joint hair.

In addtion to unbranched hairs on the basal joints of the ninth pair of legs the terminal joint of the leg is also peculiar. It is long, curved at the end and with slight indications of a division. There are no ventral spines or hairs visible in the type.

Specimens were collected at Puddingstone canyon, not far from San Dimas, California, March 1, 1929.

The distinctive characters are as follows: Peculiar distribution of spatulate and short cylindrical spines on the basal segments of the legs; the peculiar character of the last leg, both as to basal spines and terminal joint and flagella of the globulus branch of the antenna.

The type, a male in the Pomona College collection. Injured in study.

Stylopauropus simplus n. sp. (Figure 13.)

Length 1.06 mm. Width of the head not clearly seen in the type, but in another specimen of the same length the width was .12 mm. and the body at its widest part was .24 mm. The total length of the antenna was .13 mm. and its base was .05 mm. long. The basal joint of the globulus branch of the antenna was thicker than the other but not much more than half as long as the other. The stalk of the globulus was slightly longer than the diameter of the globulus. All three of the flagella were of the same length in the type. The eye areas were rather small. The head bears simple hairs.

The distribution of the dorsal hairs is as follows:

The head has six or seven cephalic marginal hairs and a pair of more caudal ones. The first two body segments each bear a pair of

hairs. The third body segment has a pair of hairs in front and two pairs farther back. The fourth segment has three pairs of two each as does the fifth and sixth regions, but in the first case one pair is centro-caudal and in the last two segments the corresponding pair is centro-medial.

The caudal end has three long more or less terminal hairs and the anal plate has a central body bearing two short hairs and on each side of this a single small hair.

The plume hairs are as follows: First, .12 mm. long; second, .13 mm.; third, .12 mm.; fourth, .13 mm.; fifth, .16 mm.

The leg lengths are as follows: First, .09 mm.; second, .12 mm.; third, .13 mm.; fourth, .13 mm.; fifth, .15 mm ; sixth, .16 mm.; seventh, .16 mm.; eighth, .17 mm.; ninth, .20 mm.

The leg proportions, beginning with the longest joints are as follows: First, 6–5–2–3–1; second, 6–4–2 3–1–5; third, 6–4–3–2–1–5; fourth, 6–4–3–2–1–5; fifth, 6–4–3–2–1–5; sixth, 6–4–2–3–1–5; seventh, 6–4–2–3–1–5; eighth, 6–4–(3–2)–5–1; ninth, 5–4–(3–2)–1. The basal joint hairs slender. These hairs are biramous on the ninth basal leg joints.

Specimens were collected from San Tomas, Lower California, December 20, 1927.

The distinctive characters are as follows: The peculiar hairs and medial structure of the anal plate; not very large eyes; antennæ with basal globulus portion longer than the other basal branch of the antenna and with all flagella about equal in size.

The type is a female in the Pomona College collection.

Stylopauropus oregonensis n. sp. (Figure 14.)

Length .88 mm., general proportions as usual. Length of antenna, .18 mm., of which .04 mm. is the length of the basal four joints. Basal joints of the flagella about the same length. One flagellum of the globulus division shorter than the other. Globulus itself on a long stalk. This stalk is three times the diameter of the globulus diameter.

The hairs of the head are short clubs.

The distribution of dorsal setæ is as follows:

The head has a cephalic marginal row of six hairs, three on each side, and a caudal row of four. The first body segment has a row of four setæ. The second segment has a row of four hairs, two on each side. The third thoracic segment has a row of four and then a row of two hairs. The fourth segment has a row of two and then a row of four hairs. The fifth division has two rows of two hairs on each side. The sixth segment has a row of two and a row of four hairs.

The caudal region has three long hairs on each side. In the middle line the anal plate has two small central hairs and two smaller hairs, one each side of the larger pair, or four minute hairs in all.

The last plume hair was .12 mm. long, the others were not perfect in the type specimen, but judging from other material they were all shorter than this.

The lengths of the legs were as follows:

First leg, .09 mm.; second leg, .09 mm.; third leg, .13 mm.; fourth leg, .15 mm.; fifth leg, .16 mm.; sixth leg probably .16 mm.; seventh leg, .16 mm.; eighth leg, .16 mm.; ninth leg, .17 mm.

The proportions of some of the leg joints are as follows, beginning with the longest joint in each leg:

First leg, 5–2–3–1–4; second leg, (2–6)–3–4–2–5; third leg, the same as the last; ninth leg, 5–4–3–2–1.

The spines on the basal joints differ greatly. They are as follows:

First leg, basal joint one small flat spine; the second basal spine is double having one large and one small flattened scale.

The second leg is similar to the last with one small flat spine on the first basal joint and two on the second basal joint with one of these last much smaller than the other.

The third leg has a small flat spine on each of the two basal joints.

The fourth leg is like the last with the flattened spines larger.

The fifth leg has a small rounded spine on the first basal joint and two flattened spines attached to the second joint. One of these is three times the size of the other.

The sixth leg is similar to the fifth. The seventh leg is similar but the two spines or flat hairs on the second basal joint are nearly of the same size. The eighth is also similar but with the basal spine a little larger and possibly double.

The ninth leg has two small spines on each of the two basal leg segments. These spines are short and broad and one in each set is larger than the other.

There is a fine pubescence on the last three joints of the last pair of legs. The claws are rather prominent but rather blunt.

Ventral to the legs there are a few irregularly scattered hairs.

Several specimens were found on the slope of Mt. Hood, Oregon, at about six thousand feet altitude, August 15, 1929. One was an immature with three pairs of legs.

The differential points in this species are the following: The peculiar and variable distribution of basal joint spines. The character of the anal plate. The peculiar fine pubescence on the last three joints of the last three legs and the general character of the antennæ. The eyes are also the smallest of any examined in this genus. The hairs of the head are short clubs, in part at least.

The type specimen is a male in the Pomona College collection. The male reproductive opening differs markedly from the male organ in the species *S. locatus*, as shown by the figures.

GENERAL REMARKS.

Although the species just described seem distinct from each other, there are a few similarities as follows:

P. californianus resembles *P. indigenous* more closely than any other described.

Pauropus medius is quite close to *P. pinus*. This is especially shown in the anal plate region. They are of the same type, but differ in detail.

In comparison with other species described in the past there are a few similarities in single characters as follows:

The anal plate region of *P. danicus* Hansen, resembles the anal plate of *Stylopauropus locatus*.

The antennæ of *P. huxleyi* Lubbock as figured by recent writers such as Hansen and others, resembles that of *P. caudaspinosus* in general form and proportions.

The anal region of *P. intermedius* Hansen is much like that of *P. caudaspinosus*.

The anal region of *P. inornatus* Hansen is somewhat like that of *Stylopauropus locatus*.

BIBLIOGRAPHY.

Attems, C. G. 1914. Die Indo-Australischen Myriopoda. Arch. Natg. Berlin. Heft. 4, pp. 1–398.

Bagnall, R. S. 1909. Notes on some Pauropoda from the counties of Northumberland and Durham. Trans. Hist. Soc. Newcastle, 39, pl. 2, pp. 462–6.

1911. A synopsis of the British Pauropoda. Trans. Hist. Soc. Newcastle, new ser. 3, pl. 3, pp. 657–8.

1914. Notes on Pauropoda with a brief description of a new species. Trans. Nat. Hist. Soc., Newcastle, 4, pp. 59–60.

1918. Records of some new British Diplopods and Pauropods, with a preliminary list of the British Myriapods. Jour. Zool. Research London, 3, pp. 87–93.

Cook, O. F. 1896. An enumeration of the Pauropoda. Brantia, iv.

Dady, E. 1889. Myriapoda Regni Hungariae, Budapest.

Haase, E. 1885. Schlesiens Symphylen u. Pauropoden. Breslau. 15 pp.

Hansen, H. J. 1901. On the genera and species of the order Pauropoda. Vid. Medd. pp. 323–424, Pls. i–vi.

Harrison, L. 1914. On some Pauropoda from New South Wales. Proc. Linn. Soc. N. S. Wales, 39, pp. 615–634, pls. 20–21.

Kenyon, F. C. 1895. The Morphology and Classification of the Pauropoda, with notes on the morphology of the Diplopoda. Tufts College studies iv, pp. 77–142, pts. i iv.

Latzel, R. 1884. Die Pauropoden Osterrichs. Verhanddl. k. k. zool.-bot. Wien. 33, pp. 123–128.

Lubbock, J. 1866. On pauropus, a new type of centipede. Trans. Linn. Soc. v. 26, pp. 181–190.

Packard, A. S. 1871. A remarkable myriapod. Am. Nat., iv.

1871. Proc. Bost. Soc. Nat. Hist., xiii.

Ryder, J. A. 1879. An account of a genus of minute myriapods. Am. Nat. 13, pp. 603-612.
1878. Discovery of two remarkable Myriapods in Fairmount Park. Am. Nat., 12.
Schmidt, P. 1894. Zur Kenntnis des inneren Baues des Pauropus huxleyi. Zool. Anz., xvii.
Silvestri, F. 1905. Fauna chilensis. Myriapoda. Zool. Jahrb. Syst. suppl. vi, bd. 3, pp. 715-772; pls. 34-37.
1902. Acari, Myriapoda et Scorpions in Italia—Pauropoda. 8vo, 85 pp., 56 figs. Portici.
Tomosvary, E. 1884. Termcsz Fuzetek, vii.
Williams, S. R. and **Hefner, R. A.** 1928. The millopedes and centipedes of Ohio. Ohio Biol. Survey Bull. 18, Vol. 4, No. 3, pp. 93-147. .

EXPLANATION OF FIGURES.

FIG. 1. *Pauropus californianus n. sp.* a, antenna; b, first leg; c, dorsal view of the caudal end; d, ventral view of the anal end; e-l, spines between legs 1-8.

FIG. 2. *Pauropus medius* n. sp. a, ninth leg; b, first leg.

FIG. 3. *Pauropus indigenous* n. sp. a, caudal region from below; b, ventral spine.

FIG. 4. *Pauropus medius* n. sp. a, caudal end from below; b, antenna.

FIG. 5. *Pauropus santus* n. sp. a, caudal end from below.

FIG. 6. *Pauropus quercus* n. sp. Caudal end from below.

FIG. 7. *Pauropus globulus* n. sp. Antenna.

FIG. 8. *Pauropus caudaspinosus* n. sp. a, caudal end from below; b, ventral spine.

FIG. 9. *Pauropus pinus* n. sp. a, antenna; b, caudal end from below; c, ninth leg; d, first leg.

FIG. 10. *Pauropus mexicanus* n. sp. Antenna.

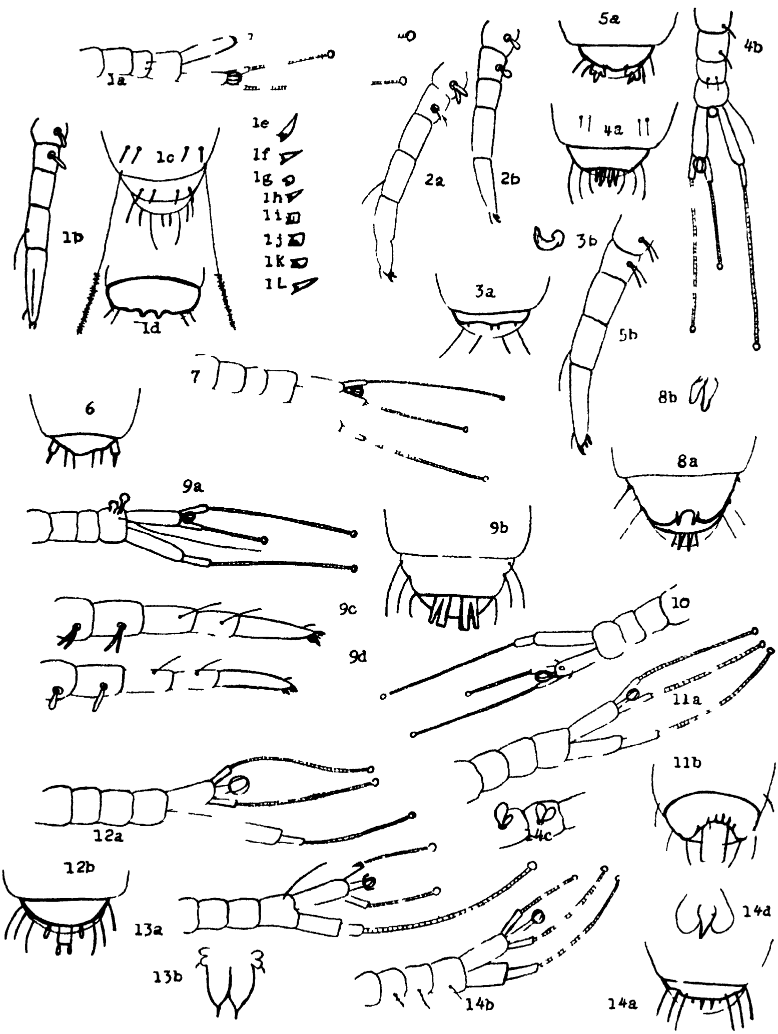
FIG. 11. *Stylopauropus digitus* n. sp. a, antenna; b, caudal end from below.

FIG. 12. *Stylopauropus locatus* n. sp. a, antenna; b, caudal region from below.

FIG. 13. *Stylopauropus simplus* n. sp. a, antenna; b, male organ.

FIG. 14. *Stylopauropus oregonensis* n. sp. a, caudal end from below; b, antenna; c, basal segments shpwing hairs, from one of the last pair of legs; d, male organ.

PLATE I.


1a
1b
1c
1d
1e
1f
1g
1h
1i
1j
1K
1L
2a
2b
3a
3b
4a
4b
5a
5b
6
7
8a
8b
9a
9b
9c
9d
10
11a
11b
12a
12b
13a
13b
14a
14b
14c
14d

THE WINTERING HABITS OF MUSCOID FLIES IN IOWA.*

R. A. Roberts,
Uvalde, Texas.

Although Muscoid flies are abundant in Iowa, references to these Diptera in current and past literature are exceedingly scarce. Very little scientific work has been done within the state either on this family or on the other families of flies which are parasitic on animals. Among these Diptera are some of the greatest pests of livestock, and the agriculturists need to turn their attention to the economic losses they are suffering from them. The present work has been undertaken as a preliminary survey of the wintering habits of the Diptera which affect man and livestock. An effort has been made to present a list of the various flies which annoy animals, breed in dead carcasses, frequent barns and houses, or are otherwise of interest. Although the actual numerical abundance of these flies has not been estimated, the relative proportion of each species is given. As this thesis contains observations over a period of only nine months it should be considered as merely the nucleus of a future knowledge of the subject. The present list of Diptera, which includes species found during the fall, winter, and spring, should be supplemented with the species which are present during the summer.

The observations which were made at Ames, Iowa were begun October 1, 1927 and ended May 5, 1928 The city of Ames is located in Story County in central Iowa, has a latitude of 42° 2′, a longitude of 93° 38′ and an altitude of 922 feet. Central Iowa was originally an oak grove savanna but is now almost entirely under cultivation. The state is located in the Carolinian of the Upper Austral faunal zone. There are no large bodies of water in this vicinity.

The winter of 1927–28 was rather moderate at Ames, with only a few periods of severe cold. On one occasion the temperature reached –25° F. Little rain and only a small amount of

*Contribution from the Department of Zoology and Entomology, Iowa State College, Ames, Iowa.

snow fell during the winter. The annual rainfall of Iowa is 31.5 inches The spring of 1928 was delayed, the cold weather lasting well into the latter part of April.

The present study was made under the direction of Dr. H. H. Knight of Iowa State College. The writer is greatly indebted to him for his interest and assistance in the work.

TABLE I

SPECIES OF FLIES TRAPPED FROM OCTOBER 2 TO NOVEMBER 26, 1927, AT AMES, IOWA.

SPECIES	Oct 2–8	Oct 9–15	Oct 16-22	Oct. 23 29	Oct 30 Nov 5	Nov 20–27	Total	Per Cent of Total Catch
Musca domestica.	103	91	27	224	147	1	593	30 97
Lucilia sericata	122	66	76	87	106		457	23 86
Phormia regina	91	70	29	67	43	2	302	15 77
Cynomyia cadaverina	96	32	25	33	28	14	228	11 91
Lucilia caesar	29	18	13	20	28		108	5 64
Calliphora erythrocephala	8	10	1	6	14	22	61	3 18
Sarcophagidæ spp	5	8	5	14	4		36	1 88
Muscina stabulans	16	15		1	1		33	1 72
Ophyra leucostoma	12	2	4	3	5		26	1 36
Fannia scalaris	6	7	4		1		18	94
Muscina assimilis	2	3	4	1			10	52
Scatophaga stercoraria			1	4	2		7	37
Fannia canicularis		2		2	1		5	26
Chrysomyza demandata			1	2			3	16
Hydrotea dentipes	1						1	05
Pollenia rudis					1		1	05
Lucilia unicolor				1			1	05
Miscellaneous	9	1		9	6		25	1 31
Total	500	325	190	474	387	39	1915	100 00
Mean temperature .	55° F	51° F	55° F	63° F	48° F	40° F		

PROCEDURE.

The methods employed in the present work for trapping and breeding flies have been made as similar as possible to those used by the United States Bureau of Entomology. The traps used in catching flies were identical with the one recommended in U. S. Department of Agriculture Farmers' Bulletin No. 857. This is an all-metal trap, made up of an outside cylindrical frame of moderately heavy galvanized iron covered with 14 mesh screen wire. Into the bottom is fitted a screen cone through which the flies enter.

Only one trap was run continuously throughout the winter. This trap was mounted on a platform two and one-half feet square, and four feet above the ground, and was located on the south side of a small wooden building. The bait generally consisted of fresh beef, about two pounds of which was placed in the bait pan each week. Occasionally the trap was baited

TABLE II

LIST SHOWING LAST RECORDED APPEARANCE IN THE FALL AND FIRST RECORDED APPEARANCE IN THE SPRING OF ADULTS OF VARIOUS SPECIES OF FLIES AT AMES, IOWA

SPECIES	LAST APPEARANCE		FIRST APPEARANCE OUTDOORS
	Outdoors	In Heated Building	
Pollenia rudis	All winter	All winter	All winter
Phormia regina	All winter		All winter
Calliphora erythrocephala	Nov 29, 1927		Mar 20, 1928
Cynomyia cadaverina	Nov 29, 1927		Mar 23, 1928
Musca domestica	Nov 26, 1927	All winter	Mar 28, 1928
Ophyra leucostoma	Nov 5, 1927		
Muscina stabulans	Nov 5, 1927		Mar 22, 1928
Sarcophagidæ spp	Nov 5, 1927		Mar 19, 1928
Lucilia caesar	Nov 5, 1927		April 28, 1928
Lucilia sericata	Nov 5, 1927		Mar 27, 1928
Cryptolucilia cornicina	Nov 5, 1927		
Stomoxys calcitrans	Oct 30, 1927		
Fannia scalaris	Oct 30, 1927		April 4, 1928
Fannia canicularis	Oct 30, 1927	Feb 3, 1928	May 5, 1928
Scatophaga stercoraria	Oct 30, 1927		Mar 28 1928
Chrysomyza demandata	Oct 29, 1927		
Lucilia unicolor	Oct 29, 1927		
Muscina assimilis	Oct 29, 1927		May 24, 1928
Gastrophilus intestinalis	Oct 23, 1927		
Cochliomyia macellaria	Oct 10, 1927		
Hydrotea dentipes	Oct 8, 1927		April 4, 1928
Cryptolucilia caesarion			Mar 21, 1928
Protophormia terrænovæ			Mar 24, 1928
Calliphora viridescens			April 21, 1928

with a rabbit, a rat, or other small animal. The flies were emptied from the trap once each week From each week's catch a random sample of 500 flies was taken and determined as to species When the catch was less than 500 flies the entire lot was determined

In all breeding experiments fresh ground beef was used as a breeding medium for the flies, with the exception of horse manure and straw which was necessary for *Musca domestica*

. Species of Flies Trapped.

The species of flies trapped each week from October 2 to November 26, 1927 have been identified as to species. See Table I. No flies were trapped from November 6 to November 19, because of low temperature (average daily mean temperature 34° F., average minimum 26° F.).

TABLE III.

Species of Flies Trapped from March 22 to May 5, 1928, Ames, Iowa.

Species	Mar 22–28	Mar29 Apr 4	April 15–21	April 22–28	Apr 29 May 5	Total	Per Cent of Total Catch
Cynomyia cadaverina	289	275	118	316	134	1132	53 80
Phormia regina	63	183	57	135	263	701	33 32
Calliphora erythrocephala	21	13	16	9	34	93	4 42
Muscina stabulans	23	14	3	3	12	55	2 61
Calliphora viridescens			2	17	13	32	1 52
Hydrotea dentipes		4	1	6	16	27	1 28
Sarcophagidæ spp				4	9	13	62
Lucilia sericata	1			2	9	12	57
Scatophaga stercoraria	1	6	1	1		9	43
Fannia scalaris		1		5	2	8	38
Muscina assimilis	3	2	1		1	7	33
Lucilia caesar				1	5	6	29
Pollenia rudis	1	2				3	14
Musca domestica	1			1	1	3	14
Protophormia terrænovæ	1					1	05
Fannia canicularis					1	1	05
Miscellaneous			1			1	05
Total	404	500	200	500	500	2104	100 00
Mean temperature	52° F	51° F	38° F	46° F	62° F		

The house fly was the most abundant species, being predominant over other species the last two weeks before cold weather. The next five species of greatest abundance were all blow flies of economic importance

In Table II are listed the species of flies taken, showing the last date in the fall and the first date in the spring on which adults of each species were observed active under outdoor conditions. As shown, *P. rudis* and *P. regina* were taken outdoors at intervals throughout the winter. *P rudis* and *M. domestica* were present in heated buildings during the entire winter.

The species of flies caught during the spring months are given in Table III. No flies were trapped from April 5 to April 14 because of low temperature, (average daily mean temperature, 40° F., average minimum 29° F.). It is interesting to note that more than 50 per cent of the total spring catch was flies of the species *C. cadaverina.* This large fly appeared early in the spring and seemed very hardy and resistant to low temperatures. *P. regina,* which represented 33 per cent of the catch, increased rapidly in late April and early May, and became predominant over *C. cadaverina.* It is surprising that the species of *Lucilia* were represented in such small numbers, as Bishopp (1915) and others record this genus as appearing very early and abundantly in the spring, especially is *L. caesar* known to be an early spring breeder. *Lucilia,* however, did appear to be more abundant in wooded areas, where specimens were taken frequently with a net.

Discussion of Species

The following list contains all the species of flies trapped, collected, or observed from October 1, 1927 to May 1, 1928. The families of Diptera are arranged in the order accepted by Comstock (1925) and the genera of Calliphoridæ are listed as presented by Shannon (1923). The determinations of the various species were made by the author unless otherwise noted.

Family CORDYLURIDÆ.

Scatophaga stercoraria Linn. The yellow dung fly is abundant in Iowa. The species was taken in large numbers flying about cattle pastures as late as October 30

Family ORTALIDÆ

Chrysomyza demandandata Fab. *C. demandata* was common during October, when it was frequently trapped over a meat bait.

Family ANTHOMYIIDÆ.

Fannia canicularis Linn. The lesser house fly was trapped in the fall until October 30. A single female was found on February 3 flying about a heated basement room. This room was used to house small animals and it is likely that this fly was breeding in the animal excrement. Numerous specimens were observed later in February and in early March flying about dwellings.

Fannia scalaris Fab. (Laake, det.). During the fall months *F. scalaris* was more abundant than *F. canicularis*. It appeared early in April but in small numbers.

Hydrotea dentipes Fab. Although this species did not appear during the fall, it was trapped early in the spring and continued to be noticeably abundant.

Ophyra leucostoma Weid. This fly appeared regularly in meat baited traps as late as November but failed to make its appearance in the spring.

Family GASTROPHILIDÆ.

Gastrophilus intestinalis DeG. On October 23 females were observed ovipositing on animals in pastures. Eggs were being deposited by the hundreds on the forelegs, the belly, and well up on the sides and shoulders of the horses. The animals were greatly disturbed by the actions of the adult flies.

Family OESTRIDÆ.

Hypoderma lineata DeG. In Iowa larvæ of *H. lineata* reach the backs of cattle about January 8 to 20 (Bishopp and Laake 1926). The author took specimens from the backs of cattle during the latter part of January, numerous specimens in early February and grubs which were apparently mature on February 22. Cattle slaughtered at Ames, Iowa during February were often so severely infested that meat on the back was damaged to such an extent as to necessitate its removal from the carcass. Most of the cattle slaughtered at this time were Shorthorns 12 to 16 months of age. Larvæ of *H. lineata* were found in the backs of cattle as late as April 18.

Hypoderma bovis Vill. On April 18 a dairy herd near Ames, Iowa was inspected and 25 specimens of *Hypoderma* were collected from the backs of the cattle. Of these, two specimens proved to be *H. lineata* and the remaining 23 were *H. bovis*.

Family CALLIPHORIDÆ.

Calliphora erythrocephala Meig. The author bred *C. erythrocephala* throughout the winter in a greenhouse. Four generations were produced between October 31 and March 25. This species during the period under observation in the greenhouse was furnished bananas for food and given ground beef on which to oviposit. The flies showed great vitality, and did not seem to suffer or decrease in size or activity in successive generations. *C. erythrocephala* was one of the last species to disappear in the fall. It was trapped over meat baits on November 27, and was observed flying about on November 29. It was the first fly to appear in large numbers in the spring, though it was soon replaced by more abundant species. In a test to determine the depth at which larvæ of this species pupate, it was found that at a temperature of 70 to 80° F. the larvæ pupated at an average depth of 1.9 inches. Under outside conditions larvæ and pupæ of *C. erythrocephala* were removed

from the soil at a depth of from 1½ to 2 inches. This soil contained grass roots but had little surface protection. These findings indicate that shallow pupation is common with Calliphorid flies. Early stage larvæ of *C. erythrocephala* were taken outdoors in large numbers during January. These larvæ were placed, together with the meat on which they were feeding, both on the surface and one inch below the surface of the soil. None of these larvæ completed development. In a test to determine the depth from which adults of *C. erythrocephala* would emerge from buried pupæ it was found that flies would emerge through 18 inches of closely packed fine sandy loam from 22 per cent of pupæ buried. Flies failed to emerge from greater depths.

Calliphora viridescens Desv. This fly was not present during the fall months but appeared abundantly in the spring. The first specimen was trapped over beef bait April 21.

Cynomyia cadaverina Desv. *C. cadaverina* represented more than 50 per cent of the total flies trapped during the spring It was observed that large numbers of *Cynomyia* larvæ were killed by the first low temperatures without having made any effort to migrate. It is likely that only those larvæ which have passed the larva feeding stage and are ready for migration begin hibernating on the approach of cold weather. Larvæ of *C. cadaverina* in the prepupal stage were taken from the soil on February 12. These larvæ pupated at once and adult flies soon emerged. Flies of this species failed to overwinter as adults, though numbers of them were placed in locations with varying amounts of protection. Pupæ were found under winter conditions from 1½ to 2 inches below the surface of the soil.

Lucilia sericata Linn. The green-bottle fly was by far the most abundant Calliphorid fly at Ames in the fall. However, it did not appear abundantly in the spring although it was recorded early in small numbers. A stock of this species was obtained January 22 and bred under greenhouse conditions for the remainder of the winter. In the greenhouse the period from the egg to the emergence of the adult was from 16 to 23 days. While confined in cages *L. sericata* oviposited freely on banana as well as on beef. Larvæ of this species pupated at an average depth of 1.37 inches, pupation occurring in fine sandy loam at a temperature of 70 to 80° F.

Lucilia caesar Linn. ,The presence of *L. caesar* at Ames seems to run parallel with that of *L. sericata,* although the latter species was at all times more abundant. In April the writer found a large number of pupæ under the carcass of a dog which had lain all winter and did not appear to have been infested with maggots since the preceding fall. From all these pupæ emerged *L. caesar*, which suggests that this species had wintered as larvæ and pupated in April.

Lucilia unicolor Town. A single specimen of this species was taken on October 29. The fly entered a trap baited with beef.

Lucilia sylvarum Meig. (Laake Det.). Although *L. sylvarum* was not taken by the author, it is a common Iowa species. A specimen was furnished by Mr. E. W. Laake which he collected at Ames, September 17, 1919.

Phormia regina Meig. In Iowa the black blow fly is very abundant, both in the fall and spring. Adults were taken throughout the winter on warm sunny days. They were observed often in large numbers and apparently wintered over in adult form. Although active on all warm days, *P. regina* failed to oviposit even in the most favorable locations.

Protophormia terraenovæ Desv. Although this fly is a winter breeder and exceedingly abundant throughout the northern United States, it was only rarely taken at Ames. No reason can be assigned at this time for its scaricity.

Cochliomyia macellaria Fab. In late September this fly was observed breeding abundantly in refuse near a slaughter house. With the first cool weather it quickly disappeared, the last specimen being trapped October 10. The species did not appear in the spring. Observations indicate that this fly migrates from the South each summer.

Pollenia rudis Fab. Adults were frequently found throughout the winter in and about dwellings. They were also trapped both in spring and fall over meat baits. In February this species was observed active out-of-doors.

Family SARCOPHAGIDÆ

Sarcophaga haemorrhoidalis Fall. (Laake, Det.). These large Sarcophagids were trapped both in the fall and spring months.

Sarcophaga communis Park. (Laake, Det.). This was the most abundant Sarcophagid at Ames during the fall.

Sarcophaga bullata Park. (Hall, Det.). A species which was often taken in traps during early October.

Sarcophaga falculata Pand. (Hall, Det.). Adults were common during May, when they were trapped frequently.

Sarcophaga helicis Towns. (Hall, Det.). A single specimen was trapped over beef bait on May 5.

Family MUSCIDÆ

Musca domestica Linn. The house fly was the most abundant fly at Ames during the fall months. However, with the first cold weather they disappeared under outside conditions and were found only in heated buildings. *M. domestica* was bred all winter under greenhouse conditions, horse manure and oats being used as a breeding medium. Two fly traps were kept running during the winter in a heated building which housed rats and chickens. Numerous flies were caught in these traps, and larvæ were found in the animal excrement in the cages. Frequently during the winter adults of the house fly were observed flying about restaurants and residences. Fifty house fly pupæ were placed out-of-doors on January 8. These pupæ were covered with one inch of sand and a few leaves. No adults emerged, which probably was due to inadequate protection by the sand.

Muscina stabulans Fall. *M. stabulans* is very numerous in Iowa, and appeared early in the spring in large numbers.

Muscina assimilis Fall. This species is less abundant than *M. stabulans* but seems to have the same seasonal distributions, breeding habits, etc.

Cryptolucilia caesarion Meig. Numerous adults of this species appeared in the spring and were taken with a net. Large numbers entered buildings and were collected while buzzing about the window panes. Hendrickson (1925) collected adults during August.

Cryptolucilia cornicina Fab. (Laake, Det.). Two specimens of *C. cornicina* were taken October 30 on mullein plants (*Verbascum thapsus* L.).

Stomoxys calcitrans Linn. The stable fly was abundant during October. Large numbers of adults, feeding on cattle in pastures, were taken with a net as late as October 30. The emergence of the flies in the spring was evidently delayed by cold weather, as no specimens were taken.

Haematobia irritans Linn. The horn fly was frequently observed during the fall months. During October the flies were annoying cattle. In the spring the species was notably scarce.

LITERATURE CITED.

Bishopp, F. C. 1915. Flies Which Cause Myiasis in Man and Animals. Some Aspects of the Problem. J. Econ. Ent., Vol. 8, No. 3, pp. 317-329.

Bishopp, F. C., Laake, E. W., and Parman, D. C. 1926. Screw Worms and Other Maggots Affecting Animals. U. S. D. A. Farmers' Bull., No. 857, pp. 1-13, 10 figs.

Bishopp, F. C., Laake, E. W., Brundrett, H. M., and Wells, R. W. 1926. The Cattle Grubs or Ox Warbles, Their Biologies and Suggestions for Control. U. S. D. A. Dept. Bull. No. 1369, pp. 1-119, 38 figs.

Comstock, John Henry. 1925. An Introduction to Entounology.

Hendrickson, George O. 1926. Some Notes on the Ecology of Prairie Insects. Unpublished thesis, Iowa State College Library, pp. 1-114, 2 pls.

Shannon, Raymond C. 1923. Genera of Neartic Calliphoridae, Blow-Flies, with Revision of the Calliphorini. Insecutor Inscitiae Menstruus, Vol. XI, pp. 101-118, 3 pls.

NOTES ON SOME BOMBYLIIDÆ (DIPTERA) FROM THE REPUBLIC OF HONDURAS.*

REGINALD H. PAINTER,†
Kansas State Agricultural College.

In the early part of 1926, the author spent three months in the Republic of Honduras in research on the sandflies (biting Ceratopogoninæ) for the Medical Department of the United Fruit Company. During the time there, a number of insects, especially Diptera, were collected. Since little is known concerning the dipterous fauna of this region, the notes which follow are presented partly to fill this lack. In *Biologia Centralia Americana* (6, 10) very few species are recorded from Honduras and none of these Bombyliidæ. The several papers on Diptera of medical importance, published in the annual report of the Medical Department of the United Fruit Company and elsewhere, constitute almost our entire knowledge of the dipterous fauna of that country. The work on the sandflies was done at or near Puerto Castilla, Honduras, and dealt with the biology, immature stages and the control of some sandflies of the genera *Culicoides* and *Leptoconops*. A full report of this work has already appeared (7).

While this study was in progress, numerous trips were made through the swamp nearby. Part of this area contained typical growths of mangroves and frequent lagoons. The paths leading through the swamp were on higher sandy ground where the brush consisted of various species of palms and a number of kinds of deciduous trees. Several species of Bombyliidæ were taken along the paths and near the sandy beach. Much of the collecting was done by sweeping, and although a number of Syrphidæ and Bombyliidæ were collected, very few were taken on flowers, but mostly on or hovering about leaves or sand.

*Contribution No. 382, from the Department of Entomology.

†I am indebted to Dr. W. E. Deeks, General Manager of the United Fruit Company's Medical Department, for the opportunity of doing this collecting during the time of my studies on the sandflies. I wish to express my thanks to Dr. B. M. Phelps, Superintendent of the Medical Department, and to the other officers and employees of the Truxillo Railroad Company, for the many courtesies extended to me during my stay in the division. My thanks are also due to my wife, Elizabeth M. Painter, for help with the manuscript and preparation of the drawings.

The investigations in Honduras extended from April 1st to June 27th, 1926. During the whole time there were only about three inches of rainfall, most of which occurred during the latter part of June. A few one and two-day trips were taken to stations along the branch of the Truxillo Railroad that follows the Aguan River as far as the town of Olanchito. On these trips, the best collecting was among the bananas. A one-day collecting trip was made into the mountains south of the town of Truxillo.

The specimens, unless otherwise stated, were collected by the author and, together with the types of the new species, are to be found in the author's collection.

Genus **Anthrax** Scopoli.

1. **Anthrax albofasciata** Macq.

Four males taken April 3, 4, and 6, Puerto Castilla, Honduras.

2 **Anthrax analis** Say.

Three males and three females from Truxillo, Honduras, taken on April 11, were identified as belonging to this species as they appear to be identical with specimens from the United States. The last three segments of the abdomen of the male are clothed with silvery scales; the squamal fringe is whitish in both sexes. Among the North American specimens of this species, the number of these silvery segments and the extent of the white pile on the first segment appear to vary. The Honduras specimens were taken while hovering in the air six or eight feet above a dry path in an open pasture.

3. **Anthrax irroratus** Say

A single male specimen from Corocito, Honduras, May 9.

Genus **Hyperalonia** Rondani.

Williston (10) p. 273, has called attention to the fact that *H. morio* Fab. (*erythrocephala* Fab. et auctt.) does not possess the same characters as a number of the other species. The examination of a number of American species which have been placed in this genus shows that they fall into two groups, one with distinctly jointed style on the third antennal joint; the

other not possessing this character. To the former belong *cerberus* (Fab.), *albiventris* (Macq.), and *latreillei* (Wied.); to the latter group belong *morio* (Fab.) and others. The original generic description (8, p. 57, 58) is not clear as to the designation of the genotype. On page 57, under the general heading "Genus Exoprosopa," a key to related genera is given in which *Hyperalonia* is mentioned as separated from the others by the possession of "four submarginal cells." Eleven older species and two new species are mentioned as belonging to this genus. On the following page a key is given to three species of *Hyperalonia* occurring in Chile. *Erythrocephala* is the first mentioned. However, the Zoological Record, Vol. II, p. 649, cites the type as *erythrocephala* (auctt.) and is the earliest subsequent designation.

The Exoprosopinæ with "four submarginal cells" then consist of two genera: *Velocia* Coq. with the characters given by Coquillett (4) and Osten Sacken (6) p. 89, and with the genotype *cerberus* (Fab.); and *Hyperalonia* Rond. with the genotype *morio* (Fab.) (*erythrocephala* Fab.). The characters of the latter are as follows:

Hyperalonia belongs to subfamily Exoprosopinæ as defined by Bezzi (2). Occiput somewhat enlarged, the whole head lacking in tomentum or scales, but clothed with scattered stiff pile, which is especially thick about the antennæ and in a pit on the front. The three joints of antennæ in the ratio 2 : 1 : 5 . 5; the first cylindrical, somewhat cupped to receive the next; the second subglobular; both first and second clothed with stiff hair; the third joint linear lanceolate, tapering from base to apex and of the same structure as found in certain species of *Villa* e. i , without a distinctly jointed style. Proboscis exceeding the mouth cavity by less than the length of the antennæ. Thoracic metapleuræ at most with one or two stiff hairs. Thorax and abdomen without scales. Wings with four interradial cells (submarginal cells). R_{2+3} arising from R_s in a right angle almost the length of the crossvein before the r-m crossvein. Squamal fringe of scales. Legs clothed with narrow scales, all tibia spinose; front tarsi short and thick, a little more than twice the length of the front tibia. Claws with a minute obtuse tooth. Abdomen broad, flat, and shining, nearly twice as long as broad and considerably longer than thorax; clothed with short, stiff hairs which are longer on the sides. Male genitalia asymmetrical

The structure of the antennæ, the front legs, the nearly bare metapleuræ, and the character of the body covering are sufficient to distinguish this genus from *Velocia*.

The described species are: *morio* (Fab.), *coeruleiventris* (Macq.), and perhaps *chilensis* Rond. and *surinamensis* Rond. These may all be a single variable species.

Genus **Velocia** Coq.

4. **Velocia albiventris** (Macq.)

Two males, collected April 8 and 30, and three females, April 4, 8, and May 2, are probably of this species. They were captured along the sandy beach on the peninsula on which Puerto Castilla is situated. Apparently this species is fairly common throughout Central America and shows considerable variation in wing pattern and in the coloration of the scales on the 2nd and 3rd abdominal segments.

The costal margin of the wing is brown, the remainder grayish hyaline, usually with five brown spots of somewhat varying size and shape. One spot lies on the r-m crossvein, and on the base of the vein R_{2+3}; another small one at the base of the first M_2; another on the vein at the base of Cu_1 extending on to a part of the median crossvein; and the last on the veins at the apex of cell R_1. On the abdomen, the entire venter and dorsum of last three abdominal segments are clothed with silvery tomentum which extends in a varying amount on to segment 4. The base of the second segment is always silvery; sometimes this silvery portion extends on to the third segment. The apex of the second segment is black tomentose; the third segment and the base of the fourth is largely black tomentose, but sometimes with scattered yellow tomentum.

5. **Velocia latreillei** (Wied.).

Two females taken April 4 and May 2, on the peninsula on which Puerto Castilla is situated. Both specimens were flying over the sandy beach.

Genus **Exoprosopa** Macquart.

6. **Exoprosopa castilla** n. sp. (Fig. 2, 4, 6).

Male.—Ground color mostly black; face, first joint of antennæ, ventral abdominal segments yellowish; lower part of front, scutellum and sides of abdominal dorsum reddish; face yellow, white tomentose; style of antennæ about one-third as long as third joint; abdominal dorsum yellow tomentose; white tomentose on base of second, middle half of fourth and all of sixth and seventh segments; black tomentose on apical half of second, third, and extreme base of fourth segment; wing pattern similar to *E. pueblensis* Jaen.; first posterior cell open. Length, 10 to 14 mm.

Head and antennæ black pilose; yellowish pilose on the cheeks; face and occiput white tomentose; front brownish tomentose, (Figs. 2, 4).

Thorax yellowish pilose; a few black pile on the center of the thoracic dorsum; some black spines on the humeri, above the bases of the wings, and on the margin of the scutellum; margins of thoracic dorsum white tomentose passing through yellow and then to black tomentose in the center; sterno-pleurite white tomentose; a conspicuous tuft of white pile below the base of the wing.

Abdomen white tomentose on base of second, middle half of fourth, and all of sixth and seventh segments; black tomentose on apical half of second, third, and extreme base of fourth segment; a few black scales on fifth segment, especially in center at base and apex, remainder of abdominal dorsum yellow tomentose; first segment and base of second laterally yellowish white pilose, lateral margins of remaining abdominal segments black pilose; venter white tomentose; coxæ yellow tomentose; anterior tibia smooth; tarsal claws minute. Wing pattern similar to *E. pueblensis* Jaen. and as shown in Fig. 6.

Female.—Similar to male, the fifth and sixth abdominal segments frequently black tomentose, both dorsally and ventrally. Thoracic dorsum with lighter colored tomentum than in the male.

Type.—Male, Puerto Castilla, Honduras, April 4, 1926.

Allotype.—Female, taken at the same place and on the same date.

Paratypes.—One male, April 4; 2 females, April 6; 2 males, April 9; 5 females, April 13; 2 males, 1 female, May 11; 2 males (one specimen teneral) May 19. These specimens were collected principally along the higher ground of the swamp and on the sand dunes.

The black tomentose areas of the second and third abdominal segments are half lens-shaped and do not reach the lateral margins of the segments.

The wing pattern is similar to that in *E. pueblensis* Jaen. and *E. eremita* O. S., but this species lacks the yellow pile on the sides of each abdominal segment that *pueblensis* possesses and lacks the white crossband on the fifth segment that is present in *eremita.* Other differences are noted in the description. The three species are closely allied and may on examination of more material prove to be varieties of a widely distributed, variable species. To determine this necessitates the presence of a larger series and a detailed study of the genetalia.

7. **Exoprosopa hulli** n. sp. (Fig. 1, 3, 7).

Male.—Body grayish brown; occiput and center of abdomen black, clothed principally with yellow pile and tomentum; cresentric-like black tomentose crossbands on apices of the second and third abdominal segments, bases of fifth and sixth narrowly black tomentose, fifth and sixth segments ventrally black tomentose. Wings dark brown on the anterior and basal half, the boundary running from the apex of the subcosta through base of second M_2, Cu_1, first and second anal cells. Length, 13 mm.

Head grayish brown, lighter about the mouth, proboscis not projecting from the oral cavity; face clothed with black and yellow pile and yellow tomentum; occiput yellowish tomentose; front black pilose and yellow tomentose; antennæ blackish brown; the first joint yellowish, about one and a half times the length of the second, the third joint short, the style about equal in length to the remainder of the joint, (Fig. 1, 3).

Thorax yellow pilose and tomentose; scattered dark brown or black pile and tomentum on thoracic dorsum; base of scutellum black tomentose, spines of thorax and scutellum black.

Abdomen yellow pilose and largely yellow tomentose; a few black scales at the apex of first segment; apical cresentric black bands on second and third; a few black scales on base of fourth, apex and base of fifth, and base of sixth; some black scales on the sides of segments 2, 3, 5 and 6, and largely covering the ventral segments of 5, 6, and base of 7.

Legs yellowish brown; tarsi blackish; first tibia smooth; femora and tibiæ clothed with yellow scales, brownish in front and beneath. Wings hyaline; base brown, slightly darker at base of second M_2 and Cu_1, coloration as shown in Fig. 7.

Female.—Similar to male. The first antennal joint generally longer than in the male; the proboscis slightly projecting. The crossbands on the abdomen are sometimes narrower than described for the male with intermixture of lighter colored scales; in some cases black scales are present on the third and fourth ventral abdominal segments.

Type.—Male, Agricultural College, Miss., July 29 (F. M. Hull).

Allotype.—Female, Agricultural College, Miss., July 22, F. M. Hull.

Paratypes.—Two males, July 21 and 22, and three females, July 22 and 29 (F. M. Hull), from same locality; two females from Sikeston, Mo., August 8, a female from Atherton, Mo. (C. F. Adams), August 13, and one from Arkansas, July 6 (D. G. Hall), in the collection of the University of Arkansas; a male, Riley County, Kans., Aug. 2 (Popenoe), in the Kansas State Agricultural College collection; two males and one female,

Atherton, Mo., collected by C. F. Adams and in his collection; two males, Manhattan, Kans., Aug. 6; three females, one collected at Manhattan, Kans., Aug. 26 (R. H. Painter), and one at McAllister, Kans., Aug. 16 (D. A. Wilbur) and one at Dickinson, Texas, June (F. M. Hull).

This species is named in honor of Mr. F. M. Hull, who collected the specimens in Mississippi, and with whom the author has spent many interesting hours collecting and studying Diptera. This species which apparently is not rare in the lower Mississippi Valley, is sometimes found in collections under the name of *E. dodrans* O. S. *E. hulli* differs from that species in having the brown of the wing extending into cell second M_2, and a different distribution of pile and tomentum. This species differs also from *E. titubans* O. S. in the distribution in the brown on the wings and of the pile and tomentum.

A female taken at Maloa Farm, near Olanchito, Honduras, June 24, belongs to this species, and as it shows no greater variation than is found among the Mississippi Valley specimens, it is also designated as a paratype. In this species the tomentum of the thorax varies from largely yellowish brown to mostly black; the width of the black band on segment two varies as does the amount of black tomentum on segment three; the width of the opening of cell R_5 is variable but in no case is it completely closed.

Genus Villa Lioy.

Under this genus may be placed those species that have been described or classified in the genera or subgenera *Villa*, *Hemipenthes*, *Thyridanthrax*, *Chrysanthrax*, and *Isopenthes*, retaining some of these for the present only as subgenera, at least as far as North American species are concerned. If these are raised to generic rank, their characters will have to be redefined or limited and many new "genera" described. To use these in a wide sense as genera with the characters as at present defined by Bezzi (2) would often result in separating closely related species and in uniting unrelated ones. A few examples may be given by way of illustration. *Isopenthes*, founded by Osten Sacken in 1886, was separated from *Anthrax* (auctt.) by the presence of "three submarginal cells." Specimens of a typical

species, *V. jaennickeana* O. S., in the author's collection have three submarginal cells in both wings; two in one wing and three in the other; and two in both wings. As pointed out by Osten Sacken, *V. jaennickeana* O. S. is very like *V. sinuosa*. It appears to be only a variety of the latter species; the occurrence of three submarginal cells in this group is not even of varietal significance. *Thyridanthrax* was founded at the same time as *Isopenthes* to receive species with smooth front tibia, rounded but protruding face, short conical third antennal segments, and fenestrate wings. Thus defined, *V. miscella* Coq. would be excluded. Although agreeing in other characters, it has the front tibia with spines and the clear spots in the darker parts of the wing evanescent. Bezzi has recently admitted to this genus species with a different wing pattern or none at all. The remaining characters of the face and antennæ are identical with those found in *Chrysanthrax*. A superficial examination of the genetalia of species of Villa shows a number of diverse forms and several groups of species, but sometimes no correlation with the characters previously used. The presence of spines on the front tibia is often used to separate these genera. The author possesses numerous specimens of a species in which the females possess these spines, while the males lack them. It appears, therefore, that the species involved should be placed under a single large genus untill the smaller units can be more closely defined and others added. The subgeneric status of the various species will be discussed below.

8. **Villa (Chrysanthrax) astarte** (Wied) (9; p 637) (10; p. 279).

Eight specimens of this species were taken April 9 and 18, along the higher places on a path through the swamp north of Puerto Castilla. This species very closely resembles *V. cypris* (Meig.) (=*Anthrax fulvohirta* Wied.), the type of the subgenus. It differs from *cypris*, especially in the presence of the wide black stripe in the center of the abdomen. The fulvous tomentum is more reddish. In the male the margins of the ninth sternite are truncate on each side of the central notch. In *cypris* they are more rounded.

9. **Villa (Chrysanthrax) edititia** (Say) (syn. **Anthrax impiger** Coq.; **Anthrax sabulosa** Coq.).

Specimens of this species were taken in the sandy areas in the swamp back of Puerto Castilla, on April 4 and 9, May 2 and 11, and near Truxillo, Honduras, April 11. In body characters, this species is a *Chrysanthrax*. The genetalia are almost exactly like *V. cypris* (Meig.), the wings alone differing from the subgeneric diagnosis. *V. sabulosa* Coq. is a synonym, differing from *impiger* only in the color of the scutellum, in this species a very variable character. The types of the two species have been examined by the author. In both cases the tomentum on the scutellum is entirely yellow. In regard to specific diagnosis, Osten Sacken's (6; p. 119) redescription, which is the earliest, may be followed. Coquillett's description (5; p. 175) applies to a different species. Say's description will fit either species fairly well, but applies a little better to the one which Osten Sacken had.

10. **Villa paradoxa** (Jaen.) (Fig. 5).

This species was one of the commonest Bombyliids taken near Puerto Castilla. Two females were collected on April 4, and two on May 1; twenty-two males, April 4, 6, 7, 9, 20, and May 2 and 19. The species was found with *V. astarte*, *V. edititia* and *Exoprosopa castilla*, along the sandy trails and dunes in the dryer part of the swamp north of Puerto Castilla. The species has the body and tomentose characters similar to *Chrysanthrax*. The genetalia, however, are very different, as are the wing venation and coloration. In these characters, *V. paradoxa* is similar to *V. mira* Coq. The specimen which Osten Sacken described from Texas in Biologia belongs to this latter species, but it is not certain whether the specimens which Williston described in the supplement (10) are the same as described here. The Honduras specimens agree well with Jaennicke's description and figure of the wing. The coloration of the wings in these specimens shows considerable variation and the stumps of veins mentioned in the description may or may not be present. In one wing of a single specimen, one of these stumps forms a crossvein in the same position and "three submarginal cells" as found in *Dipalta*. If, as seems probable, this character is unstable, *V. mira* and *V. paradoxa* should

perhaps be placed in this genus. The two species may be separated as follows:

V. paradoxa.	*V. mira.*
1. Ground color of body dull black.	1. Ground color of face and most of abdomen and legs orange red.
2. Pile and tomentum mostly faded yellow.	2. Pile and tomentum mostly reddish orange.
3. A little black tomentum on center of 4th abdominal segment.	3. Black tomentum usually present on bases of 2nd, 3rd, and 4th abdominal segments and a median streak on these segments.
4. A fuscous margin along the S-shaped part of vein R_{2+3} (Fig. 5).	4. Last third of R_{2+3} largely or wholly margined with hyaline.
5. Front coxae largely yellow pilose.	5. Front coxae largely black pilose.

The ground color of the face and legs of *V. paradoxa* is darker in the male than in the female. The males of both species seem more plentiful than the females.

11. **Villa (Hemipenthes) orbitalis** (Will.).

A single male which probably belongs to this species was taken among the pines on the mountains near Maloa Farm and Olanchito, Honduras, June 21. It does not differ greatly from specimens of this species taken in Mississippi, Missouri, or Texas. The description in Biologia (10) refers to the female instead of to the male as stated there. Major E. E. Austen of the British Museum has kindly confirmed this point for me by an examination of the type. The description of the male is as follows:

Male.—Ground color of body is shining black; around oral opening slightly whitish. Pile and tomentum black; tomentum on occiput whitish, pile on anterior part of thorax and on occiput yellowish, on sides of first segment of abdomen yellowish brown tomentum, on sides of last three segments white, a small patch of yellow tomentum on the sides of segment 5. Small spines on front tibia. Wings as in the female, with basal half black, the line of division running almost straight from the apex of subcosta to apex of second anal vein.

Androtype.—Male, Clarksdale, Miss., Aug. 6, 1926.

Paratypes.—Male, Puerto Castilla, Honduras, June 21; one each from Austin, Texas, June 26; Brady, Texas, July 25; Kingsville, Texas, June 6 (F. M. Hull); Mason, Texas, Aug. 26;

Brownwood, Texas, Sept. 10; Sikeston, Mo., Aug. 8; and four specimens from Clarksdale, Miss., Aug. 6. In the specimen from Honduras, the tomentum of the face is largely yellowish. The black tomentum in the center of the last three segments also varies in amount. Sometimes this is entirely lacking on the last segment.

The female differs from the male in having considerable white pile on the pleuræ and white tomentum on the face and first ventral abdominal segment. The male of this species differs from the descripiton of the male of *V. curta* (Lw.) in several particulars, but especially in that *orbitalis* lacks the white tomentum on the first two ventral segments. The wing pattern is also different. *V. celer* Wied. differs from both these species in the presence of a yellow tomentose triangle in front of the scutellum in both sexes.

Genus **Poecilanthrax** Osten Sacken.

12. **Poecilanthrax lucifer** (Fab.).

A male and a female of this species were taken May 11 and April 4, near Puerto Castilla. In addition to the characters given by Cole (3) and Osten Sacken (6), the genus may be separated from its near relatives by the almost complete lack of any kind of scales or tomentum on the face or front.

Genus **Phtheria** Meigen.

13. **Phtheria aldrichii** Johnson.

Forty specimens of this species were taken near Puerto Castilla, April 2, 4 and 6. They were hovering over the white sand of the seashore and were collected by sweeping. This species, *P. coquilletti* Johns., *cyanoceps* Johns., and *amplicella* Coq. differ from most of the other species in the genus in the shape and size of the discal cell, the last segment of Cu_1 being about half as long as the preceding segment. The exact length of the last segment seems variable in *P. aldrichii*. In a cotype (Idaho) supplied by Dr. C. W. Johnson, the last segment is about half the length of the median crossvein; in the Honduras specimens it is about equal to the crossvein, while some Texas specimens are intermediate.

14. **Phtheria badia** Coq.

In 1904, Coquillett described the male from Brownsville, Texas. In the author's collection there are males from San Saba and Austin, Texas, and females from San Saba, Austin, and Victoria, Texas. A female taken at Puerto Castilla, Honduras, June 6, is identical with the Texas specimens. As there is no record of the female being taken before, the description follows:

Female.—Like male but with only one blackish-brown spot on upper part of cheek; faint golden-brown stripe in center of front; occiput in center yellow brown; thorax light-brown with two yellow vittæ extending nearly to the scutellum; on pleuræ light-brown; a lighter brown patch in front of scutellum interrupting the yellow vittæ, and a similar patch in center of scutellum.

Gynetype. Female, San Saba, Texas, Aug. 25.

Paratypes.—One each from San Saba, Texas, Aug. 25; Austin, Texas, Sept. 23; Victoria, Texas, June 25; and Puerto Castilla, Honduras, June 6.

I have compared the males in my collection with the type and they are identical. The spots on the face vary from brown to black. The center of the scutellum and of the abdominal segments are light brown in both the male and female, thus darker than the surrounding parts. The specimens from San Saba, Texas, Aug. 25, were taken on sunflowers.

Genus Lepidophora Westwood.

15. **Lepidophora acroleuca** n sp.

Male.—Ground color of body opaque, dark grayish black, sides of thorax lighter; clothed with black and white scales and hairs; antennæ black, the long scales on the third antennal joint exceeding only slightly the tip of that joint; scales of abdomen black, with a small patch of white scales on the sides of segments 1, 2, 3 and 4; the remaining segments, especially the last, clothed with long, bushy scales, making the abdomen appear clavate; legs black; wings black; opaque, lighter toward the hind border and with tips milky-white. Length, 17 mm. (measuring curve formed by body and including the antennæ); wing, each, 11 mm.

Head, proboscis, and antennæ black; proboscis about equal to first two joints of antennæ, black, hairy on the sides; sides of oral cavity and beneath the head clothed with sparse black hair; face and front with long black scales, a small patch of white scales on the orbits about

midway down the face; antennæ heavily clothed with black scales, scales on the third joint only in a row along the outer side, extending from base to apex, but more numerous and longer at the base, these scales scarcely exceeding the length of the third joint; scales of the occiput long, mostly white and interspersed with stout black spines and hairs.

Prothorax large, clothed with black and white curly hairs and scales and with a row of black spines along the front and sides; mesothorax grayish black, lighter on the sides; dorsum clothed with short, black hair, black and white tomentum, the former especially in the center, black spines along the sides; sides of the thorax, venter, and coxæ with long black and white hairs; scutellum thickly clothed with black scales and long hairs and spines, a few white scales on the sides at the base.

Abdomen entirely clothed with black scales except for small white patches on the sides of the segments 1, 2, 3 and 4, a few long white hairs along the base of the first segment, and some long black ones along the sides of the abdomen; last four segments of the abdomen thickly clothed on the sides with long black scales.

Legs black, clothed with black scales. Wings black, lighter along the posterior border; veins black except at the tip; the tips of cells R_1 and R_3 beyond the base of R_4, and all of R_4 opaque, milky white; the veins in this area and bounding it light yellow; costa dentate, cells on the anterior third of the wings clothed above and below with scattered black scales; squamal fringe of long gray and black hairs; halteres white with somewhat darker stalk, clothed with white scales.

Holotype.—Male, from Puerto Castilla, Honduras, collected by the author April 20, 1926. The specimen was resting on an iron telephone post in the sun, near Empalme Junction. This species differs from the others in the genus by the milk-white tip of the wing, the distribution of the length of the scales on the third antennal joint, and the distribution of the white scales on the abdomen.

Genus Geron Meigen.

16. **Geron** sp.

Six males and one female belonging to a new species which will be described in a paper on this group which the author has in preparation.

BIBLIOGRAPHY.

(1) **Bequaert, J.** 1925. Report of an Entomological trip to the Truxillo Division, Honduras, to investigate the sandfly problem. In the 1924 Annual Report of the Medical Department of the United Fruit Company, 193–206.

(2) **Bezzi, M.** 1924. Bombyliidae of the Ethiopian Region. British Museum (Natural History). 390 pp.

(3) **Cole, F. R.** 1917. Notes on Osten Sacken's group "Poecilanthrax" with descriptions of new species. Jour. N. Y. Ent. Soc. 25: 67–80.

(4) **Coquillett, D. W.** 1886. The North American genera of Anthracina. Canad. Ent. 28: 157–159.

(5) ————. 1887. A monograph of the genus Anthrax. Trans. Amer. Ent. Soc. 14: 160–182.

(6) **Osten Sacken, C. R.** 1886, 1887. Biologia Centralia Americana. Diptera. Vol. I, 75–162.

(7) **Painter, Reginald H.** 1927. The biology, immature stages and control of the sandflies (biting Ceratopogoninae) at Puerto Castilla, Honduras. In the 1926 Annual Report of Medical Dept. of the United Fruit Co., 245–262.

(8) **Rondani, Camillo.** 1864. Dipterorum Species et Genera Aligua Exotica. Arch. per la Zool., Vol. III.

(9) **Wiedemann, C. R. W.** 1830. Auszereuropaische Zweiflugelige Insecten. Vol. II. Hamm. 684 pp.

(10) **Williston, S. W.** 1901. Biologia Centralia Americana. Diptera. Vol. I, 269–296.

EXPLANATION OF PLATE.

Fig. 1. *Exoprosopa hulli* n. sp. Lateral view of head of allotype female.

Fig. 2. *Exoprosopa castilla* n. sp. Lateral view of head of type male.

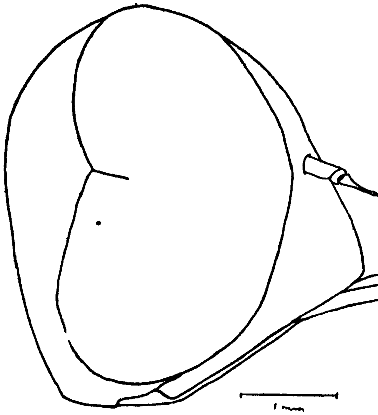
Fig. 3. *E. hulli.* Dorsal view of antenna of allotype female.

Fig. 4. *E. castilla.* Dorsal view of antenna of type male.

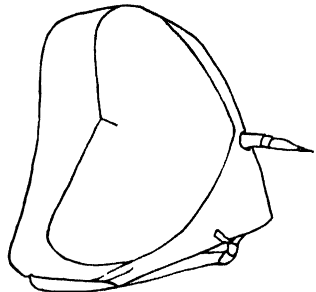
Fig. 5. *Villa paradoxa* (Jaen.). Wing.

Fig. 6. *E. castilla.* Wing.

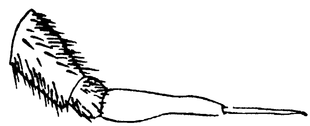
Fig. 7. *E. hulli.* Wing.



1

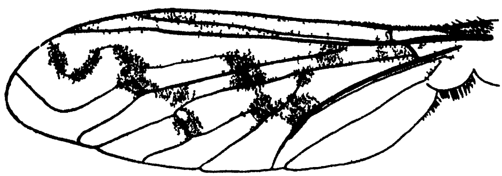


2



3

4



5

6

7

WAX SECRETION IN THE RHIZOBIINI.*

Stanley E. Flanders,
Citrus Experiment Station, Riverside, California.

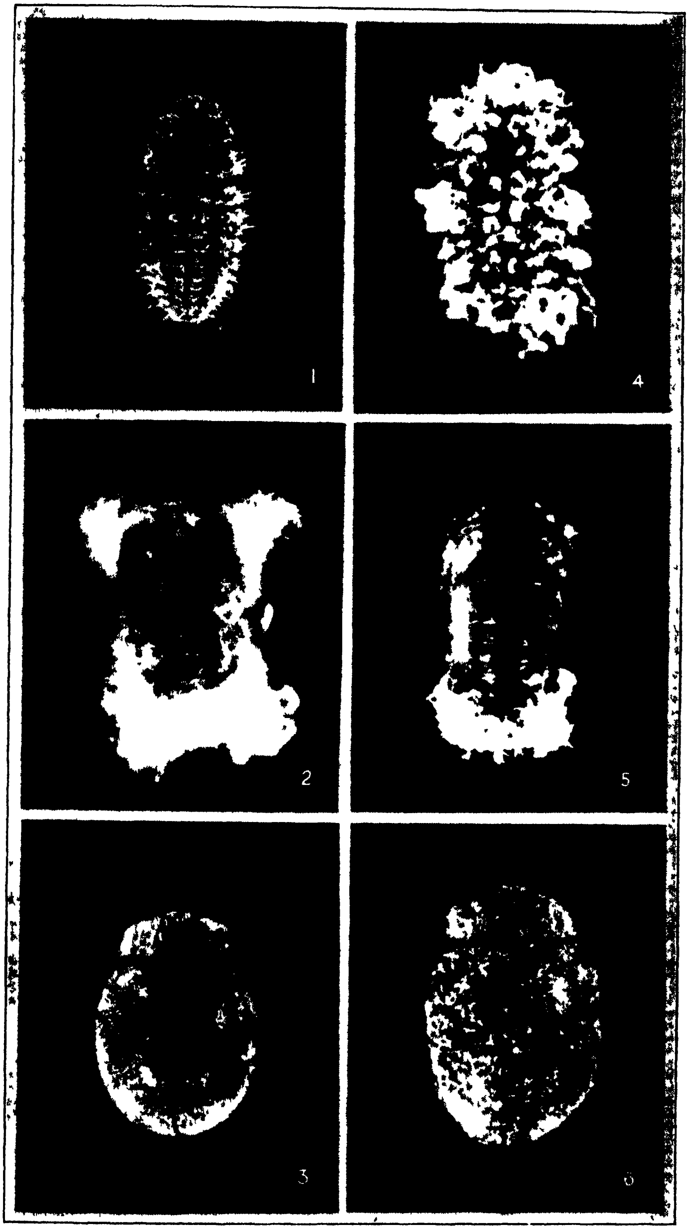
When *Lindorus lophanthæ* (Blaisdell) and *Rhizobius ventralis* (Er.) are reared in the laboratory they produce wax at every stage of their life cycle subsequent to the first larval instar.

The amount of wax secreted during the feeding period is only sufficient to give the larva a powdery appearance. After the larva has finished feeding and is in the prepupal stage the amount of wax is greatly increased. *Rhizobius* is then completely covered with a mass of cottony wax. The fine long filaments of wax give it the appearance of having been attacked by mold. The dorsum of *Lindorus* is covered with tufts of wax but is not completely hidden. The outer row of six longitudinal rows of wax glands produces wax most abundantly.

The pupæ of Rhizobius is surrounded by the white filaments of the last larval instar and its olive colored integument is smooth. It secretes only a few wax filaments. The pupa of *Lindorus* is light yellow and is covered with glandular hairs which consist of short hairs about .09 mm. in length mixed with similar ones twice as long. Several hours after pupation a drop of clear liquid appears at the tip of each hair. These drops remain on the hairs long after the pupal skin is discarded. They do not evaporate even when the atmospheric humidity is below 30 per cent and the liquid does not mix with water. It is soluble in alcohol, however, and when this evaporates a waxy residue remains.

On the second or third day after the adult *Lindorus* has emerged the entire dorsum takes on a dusty appearance due to the secretion of particles of white wax. The same phenomenon occurs on the adult *Rhizobius* three to six days after emergence. This secretion of wax is limited to the young adults. The ease with which the wax is rubbed off tends to preclude its remaining on specimens living under field conditions.

*Paper No. 216, University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.



Rhizobius ventralis
Fig 1, larva; 2, pupa; 3, adult

Lindorus lophanthas
Fig 4, larva; 5, pupa; 6, adult

A NEW KEY TO PARACALOCORIS WITH DESCRIPTIONS OF EIGHT NEW SPECIES (HEMIPTERA, MIRIDÆ).*

HARRY H. KNIGHT,
Ames, Iowa.

In a previous paper (Ann. Ent. Soc. Am., xix, 1926, pp. 367–377) the writer gave a key for eighteen known Nearctic species of *Paracalocoris* Distant, also keys to the color varieties of *P. externus* H. S., *scrupeus* Say, and *hawleyi* Kngt. These keys to the color varieties are not repeated in the present article. Since the appearance of the above mentioned paper I have been able to recognize eight more new species and four new varieties, all of which are described in the present paper. Two varieties described by Mr. McAtee are now raised to the rank of species, namely, *Paracalocoris pallidulus* McA. and *P. castus* McA. To the latter species belong the varieties *colonus* McA. and *amiculus* McA. I have also included a redescription and notes on the type of *Paracalocoris adustus* McAtee.

Paracalocoris jurgiosus (Stal) is not recognized from the United States, and so far as the present material indicates, the species is actually known only from Mexico (Stal, 1862) and Guatemala (Distant, 1883). A new key is now presented for the separation of 28 species, all recognized from within the borders of the United States except *jurgiosus* Stal.

Paracalocoris celtidis n. sp.

Allied to *colon* Say and *gleditsiæ* Kngt., but easily distinguished by the longer rostrum and different color aspect.

♂. Length 5.7 mm., width 2.6 mm. Head: width 1.14 mm., vertex .56 mm.; brown with pale above, area bordering dorsal margin of eye, spot above base of antenna, and mark on median line of frons, pale; tylus and juga black, spot at dorsal angle and line along ventral margin of juga, extreme tip of tylus and spot on each side opposite tip of lora, white; lora brownish black, lower margin and extending in a broad stripe across gena to collar, white; also a white spot behind eye, thus leaving a black stripe extending back from lower margin of eye; bucculæ chiefly white, gula black. Rostrum, length 2.7 mm.,

*Contribution from the Department of Zoology and Entomology, Iowa State College, Ames.

extending behind coxæ to fifth ventral segment, pale to yellowish, last two segments black. Antennæ: segment I, length 1 mm., dark brown to black, irrorate with several white glabrous spots, set with several erect black setæ which in length only slightly exceed thickness of segment, also clothed with shorter and more recumbent black hairs; II, 2.25 mm., black, with pale annulus at middle; III, .91 mm., fuscous to black, pale at base; IV, .95 mm., black, narrowly pale at base. Pronotum: length 1.3 mm., width at base 2 mm.; disk dark brown to black, spotted with pale, calli and surrounding discal spots pale to yellowish brown, between calli and extending back along median line to base of disk, white, the pale color on basal half apparently produced by the joining of several white spots; narrow basal margin of disk white, collar brown, irrorate with white spots; propleura brown, blackish anterior to coxal cleft, marked with three white lines which are parallel to margin of pronotal disk, the third or ventral white line passing through middle of propleura. Scutellum brown with pale, the pale color due to several spots which are more or less confluent; median line pale except apex but it is joined by so many spots that the line effect is largely obscured; mesoscutum black, pale each side of middle but not on the declivent sides.

Hemelytra black, in part brownish black, irrorate with pale spots, these more prominent along radial vein and near apex of embolium. Cuneus largely white, due to the numerous and confluent white spots; apex and inner basal angles (paracuneus), black. Membrane dark fuscous or blackish, disk of larger areole, apical half of membrane except large spot bordering apex of larger areole, and spot at middle of outer margin, pale; veins white at apex of larger areole. Meso- and metathorax black, episterna with a white line, this skips the epimeron but appears bordering dorsal margin of ostiolar peritreme, the latter fuscous with mesal angle paler.

Legs pale and marked with brownish black, distal half of femora with blackish ground color which is cut into reticulations by the numerous white spots; hind femora with one much larger white spot on middle of dorsal aspect; tibiæ with apex, band at middle, and a broader band at base, brownish black, the latter somewhat broken by white spots; tarsi pale, apices black. Venter brownish black and varied with white and yellowish marks; sides more black, with three rows of obliquely placed, yellow dash marks. Genital claspers characteristic of the genus, hence not readily used for specific distinctions.

Dorsum clothed with recumbent, pale to golden yellow, sericeous pubescence, and intermixed with less prominent, simple fuscous hairs; femora with several prominent, bristle-like white hairs much as in *gleditsiæ*; tibiæ with several pale, setose hairs which may exceed length of the true spines, but the latter much thicker, brown in color and should not be easily confused.

♀. Length 6 mm., width 2.6 mm. Head: width 1.14 mm., vertex .56 mm. Antennæ: segment I, length 1.04 mm.; II, 2.03 mm.; III, .95 mm.; IV, 1.29 mm. Pronotum: length 1.34 mm., width at base 2.12 mm. Slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂ June 29, 1929, Ames, Iowa (H. H. Knight); Iowa State College collection. *Allotype:* taken with the type. *Paratypes:* 145 ♂ ♀, taken with the types on hackberry trees (*Celtis occidentalis* L) on the Curtis farm south of the College grounds. 15 ♂ ♀ June 25, 143 ♂ ♀ July 8, 1929, Ames, Iowa (H. H. Knight), taken on hackberry where the species was breeding.

To the writer, the discovery of this species was very remarkable and wholly unexpected. For a good many years, in fact since 1914 when I first began to collect Miridæ by systematically working each and every species of plant that I found, I have sought to find some species of Miridæ breeding on hackberry. In New York and Minnesota I was unsuccessful, and not until 1929 did I find the present species in Iowa, although on different occasions I had swept this tree for insects. However, collecting insects in Iowa was remarkably poor during 1926 and 1927, and not until the season of 1929 did the insects come back to normal abundance. In some future paper I hope to record more fully my observations on the scarcity of insects during the years mentioned, and point out some possible causes of the condition.

In the large series of *celtidis* listed above all specimens are very uniform in coloration, there being no indication of color varieties such as we find in *externus* H. S. and *scrupeus* Say.

Paracalocoris trivittis n n

A new name to replace *Paracalocoris trivittatus* Knight (Ann. Ent. Soc. Am., xix, 1926, p. 371), which is preoccupied by *Paracalocoris* ? *trivittatus* Reuter (Ofversight af Finska Vetenskaps Societetens Forhandlingar, LV, 1913, Afd. A. No. 18, p. 4), a doubtful species in this genus described from Peru.

The writer has found and herewith acknowledges creating his first homonym, and we hope the last one. This error was due to operating without first making a complete catalogue of known species in the family Miridæ, a condition we believe is largely corrected at the present time.

Paracalocoris evonymi n sp

Allied to *trivittis* Kngt. and *salicis* Kngt., but differs as shown in the key. First antennal segment pale and with

reticulate brown marks and spots, pronotal disk with pale median line only, metaepisternum uniformly blackish, and venter without distinct pale marks on sides.

♂. Length 6.1 mm., width 2.7 mm. Head: width 1.13 mm., vertex .54 mm.; dark brown, dorsal aspect much paler, tylus with three spots on base, one each side opposite tip of lora, and extreme apex, pale; spot at base of antenna above, dorsal margin of juga and mark near ventral margin, tip of lora, ventral half of bucculæ, spot on gena, and gula largely, pale. Rostrum, length 2.25 mm., reaching to middle of hind coxæ, pale, apex black. Antennæ: segment I, length 1.25 mm., pale, with reticulate marks and spots brown, rather thickly clothed with half erect black hairs, with five or six longer setæ; II, 2.25 mm., extreme base black, bordered by a pale annulus, then yellowish brown to middle, where a slightly paler annulus separates the black on apical half; III, .97 mm., pale, distal half black; IV, 1.12 mm., blackish, paler at base. Pronotum: length 1.38 mm., width at base 2.12 mm.; dark brown, disk with a few pale spots, median line pale although it may be obsolete near basal margin, basal edge pale; discal spots opaque black, inner and outer margins bordered by pale, but not produced backward into rays as in *trivittis;* spots on collar above and lateral margin of disk delimited by a pale line; propleura brown, a small white line passing across lower half of coxal cleft. Sternum and pleura blackish, basalar plate pale, usually a pale mark on side of sternum, but without a trace on metaepisternum; ostiolar peritreme fuscous, paler on mesal angle. Scutellum dark brown, median line slenderly pale, small spot near each basal angle and a few even smaller dots near middle and apex, pale; in paler specimens the brown largely blended with pale so the median line becomes obsolete.

Hemelytra dark brown to blackish, inner half of clavus bordering scutellum more distinctly black, corium with a few obsolete pale spots, radial vein pale on basal half. Cuneus dark brown, outer edge and across middle largely pale, the pale on discal area appearing more as spots. Membrane dark fuscous to blackish, a rather large spot on margin behind apex of cuneus and a smaller one on middle of larger areole, pale; vein about apex of larger areole pale. Legs pale, base of coxæ more or less fuscous, apical half of femora spotted or reticulate with brown marks, the brown on apical third of hind femora dark enough to display a few pale irrorations; tibiæ with two brown bands, the apices scarcely darkened, hind pair with distinct brown spines and a few short hairs that do not attain the length of the spines; tarsi pale, apices blackish. Venter dark brown, more blackish at sides, ventral surface pale on basal half; sides rather uniformly brownish black except on second, or first visible segment, where two more or less obsolete pale marks occur.

Dorsum clothed with yellowish to golden, recumbent sericeous pubescence, and intermixed with a few obscure simple hairs.

♀. Length 5.8 mm., width 2.8 mm Head: width 1.16 mm., vertex .56 mm. Antennæ: segment I, length 1.21 mm.; II, 2.2 mm.;

III, 1 mm.; IV, 1.12 mm. Pronotum: length 1.35 mm., width at base 2.16 mm. Slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂ July 1, 1929, Ames, Iowa (H. H. Knight); Iowa State College collection. *Allotype:* taken with the type. *Paratypes:* 45 ♂ ♀, taken with the types on Waahoo or spindle tree (*Evonymus atropurpureus* Jacq.) where the species was breeding. 27 ♂ ♀ July 12, 130 ♂ ♀ July 13, 1927, 30 ♂ ♀ July 11, 1928, 45 ♂ ♀ July 11, 1929, Ames, Iowa (H. H. Knight), all taken on the same group of Waahoo bushes in the valley just north of the College cemetery. This interesting shrub is doubtless the only host plant used by the bug. The writer also has a single male specimen taken August 13, 1916, near Otto, Cattaragus County, (H. H. Knight), taken in sweeping and doubtless far from its host plant as no additional specimens could be found. I have always considered this specimen as distinct but hesitated to describe it from an isolated specimen. Another odd specimen should be recorded, ♀, June 21, 1918, Mercer County, Ohio (R. F. Hussey).

In the large series at hand this species shows no tendency to color varieties such as we have in *scrupeus* Say, *externus* H. S. and *severini* Kngt.

Paracalocoris albifacies n. sp.

Runs in my key to the section having first antennal segment equal to or greater than width of head, but easily distinguished from other species by the chiefly white color and black pubescence.

♀. Length 6.5 mm., width 2.86 mm. Head: width 1.23 mm., vertex .63 mm., uniformly yellow, frons paler, pubescence pale except on vertex where it is black; eyes yellow behind but with black spot on dorsal half, facets black. Rostrum, length 2.25 mm., reaching to near middle of hind coxæ by measurement, yellow, apex black. Antennæ: segment I, length 1.25 mm., pale whitish, slightly infuscated at base, clothed with short black hairs, also with a few more erect black setose hairs, but length of these not equal to thickness of segment; II, 2.73 mm., pale to yellowish, gradually becoming brown on apical half, clothed with short black pubescence, also with a few short, erect, fine pale hairs; III, 1.17 mm., brown, pale at base; IV, .96 mm., reddish brown, narrowly pale at base. Pronotum: length 1.49 mm., width at base 2.34 mm.; yellowish to white, more yellow on basal margins of calli, a fuscous mark near anterior angles of disk, beginning in the collar constriction and extending back to outer front margin of callus; discal

spots opaque black, rather small for size of specimen; basal submargin of disk with obsolete brownish reticulations apparent; propleura uniformly white. Scutellum uniformly white, finely pale pubescent; mesonotum yellowish, black along the dorsal edge of the declivent lateral area.

Hemelytra white, opaque, apex of cuneus black, apical area of corium with dark brown cloud, largely broken by white irrorations, middle of clavus with paler brown and likewise broken by pale spots. Membrane dark brown to blackish, anal area, bordering apex of cuneus, and apical area of membrane more blackish, veins white.

Dorsum clothed with short, appressed, in part sericeous, black pubescence, intermixed with some pale to yellowish pubescence on the white areas of hemelytra; scutellum with pale pubescence only; venter and basal half of femora with white pubescence.

Ventral surface white to yellowish, a fuscous dot on episternum of mesothorax, the small sclerite at base of wing joint also black Legs white, tarsi black; apical half of femora and tibiæ with short stiff black hairs, femora with several spine-like hairs that are nearly as heavy as spines on tibiæ; hind femora with a small irregular brown mark on antero-ventral margin near apex.

Holotype: ♀ October 11, 1928, Santa Cruz Co., Arizona (A. A. Nichol): author's collection.

This species is so entirely different in aspect from other known species that it may be safely described from the unique female. Mr. Nichol sends no remarks about this capture.

Paracalocoris johnstoni n. sp.

Allied to *limbus* McA. but differs in the longer first antennal segment and in the uniformly silvery white pubescence; general coloration black with red, the pattern very suggestive of *severini* var. *nigriclavus* Kngt.

♂. Length 7.1 mm., width 2.9 mm. Head: width 1.18 mm., vertex .54 mm.; red, tylus blackish, frons slightly infuscated. Rostrum, length 2.47 mm., reaching to near middle of hind coxæ, blackish. Antennæ: segment I, length 1.64 mm., black, thickly clothed with black hairs, beset with a few more erect black setæ; II, 2.82 mm., black, thickly clothed with short black pubescence; III, 1.16 mm., black, narrowly pale at base; IV, 1.08 mm., pale to slightly dusky. Pronotum: length 1.52 mm., width at base 2.3 mm.; red, posterior half of disk black except median line and slender basal margin; discal spots rather large, velvety black. Scutellum red, sometimes becoming blackish; mesoscutum red, becoming blackish on middle.

Hemelytra black, cuneus and embolium uniformly red, the corium exterior to radial vein usually red. Membrane and veins uniformly black. Ventral surface red, genital claspers and ventral surface of genital segment blackish. Legs uniformly black, however with reddish

tinge apparent through the black, coxæ reddish to blackish. Hind tibiæ with spines prominent, pubescent hairs short, recumbent, not at all obscuring the spines. Dorsum rather thickly clothed with recumbent, in part sericeous, silvery white pubescence; ventral surface with white pubescence, that on femora pale to dusky.

♀. Length 6.9 mm., width 2.86 mm. Head: width 1.15 mm., vertex .52 mm. Antennæ: segment I, length 1.68 mm.; II, 2.77 mm.; III, 1.13 mm.; IV, 1.08 mm. Pronotum: length 1.47 mm., width at base 2.21 mm. Slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂ April 16, 1929, College Station, Texas (H. G. Johnston); author's collection. *Allotype:* taken with the type; returned to Mr. Johnston. *Paratypes:* 5 ♂ ♀ April 5, 9 ♂ ♀ April 17, 5 ♂ ♀ April 24, 1928, 7 ♂ ♀ April 8, 5 ♂ ♀ April 16, 1929, College Station, Texas (H. G. Johnston). Mr. Johnston reports that he has found this species breeding only on *Smilax* sp., and never very abundant. The writer takes pleasure in naming this species after Mr. Johnston, a new student of the Miridæ.

Paracalocoris maculosus n. sp.

Distinguished from allied species by the long second antennal segment which in length exceeds the basal width of pronotum; ground color dark brown, dorsum with many small pale marks, apical half of corium with small white spots only.

♂. Length 5 mm., width 2.4 mm. Head: width 1.09 mm., vertex .49 mm.; dark brown, gula, broad stripe on gena, bucculæ except dorsal margin, ventral margin of juga, and spot each side on apical half of tylus, white; vertex, frons and marks on basal half of tylus, yellowish, frons with six or seven fine, oblique brown lines, a small wedge-shaped brown mark each side of vertex with its base against margin of eye. Rostrum, length 1.95 mm., nearly attaining posterior margins of hind coxæ, yellowish to dark brown, apex black. Antennæ: segment I, length .87 mm., dark reddish brown, with several small pale spots; II, 2.2 mm., black, basal half brownish to black, a narrow pale annulus at middle, also a nearly obsolete narrow pale annulus at base; III, .87 mm., black, pale at base, also a narrow pale annulus evident at middle although usually obsolete; IV, .83 mm., black, narrowly pale at base.

Pronotum: length 1.21 mm., width at base 1.96 mm.; ground color dark brown to blackish, collar, anterior margins of calli, arcuate parenthesis marks inclosing discal spots and central area of disk, spots along median line and four or five at each side, narrow basal margin, and three longitudinal lines on propleura, white. Scutellum dark brown, median line and two stripes each side, white. Hemelytra dark brown

to blackish, clavus with two longitudinal rows of spots, corium with short stripe on basal angle, also along basal half of radius, several rounded spots on apical half of corium and embolium, narrow edge of cuneus and embolium, and spots on disk of cuneus, white or slightly yellowish. Membrane dark fuscous to blackish, discal area of larger areole, spot at outer margin behind cuneus and extending toward middle of membrane, slightly paler; veins blackish, white about distal end of larger areole. Ventral surface brown and marked with white, venter with obliquely curving arcs of white, genital segment more brown and with pale spots on the sides. Legs pale to reddish brown, femora with numerous small white spots, hind pair with a rather large white patch on dorsal aspect at middle of apical half; hind tibiæ with two broad pale bands, these separated by brown band at middle, apices brownish, front and middle tibiæ more evidently triannulate with pale and brownish; tarsi brownish, apices blackish.

Dorsum strongly shining, clothed with fine, short, golden yellow to dusky pubescence, venter with pale pubescence

♀. Length 5.2 mm., width 2.6 mm. Head: width 1.12 mm., vertex .52 mm. Antennæ: segment I, length .93 mm.; II, 2.2 mm; III, .86 mm.; IV, .82 mm. Pronotum: length 1.32 mm, width at base 2.05 mm. More robust than the male, but very similar in pubescence and coloration.

Holotype: ♂ July 27, 1917, alt. 8500 ft., Mt. Lemon, Santa Catalina Mts., Arizona (H. H. Knight); author's collection. *Allotype:* same data as the type. *Paratypes:* 20 ♂ ♀, taken with the types. *Paratypes:* 66 ♂ ♀ July 18, 1917, Gowdy Creek Canyon, near Bonita, Arizona (H. H. Knight), taken on a white flowering *Ceanothis*, and judging by the numbers taken the species must have been breeding on that plant. 5 ♂ ♀ June 15, 1924, ♂ ♀ Sept. 26, 1925, ♂ June 26, 1926, alt. 5000 ft., Santa Rita Mts., Arizona (A. A. Nichol). 4 ♀ Aug. 1, 1927, Huachuca Mts.; ♂ Aug. 13, 1927, Coconino County, Arizona (R. H. Beamer).

This is the species that in the past, the writer as well as Mr. McAtee took to be *jurgiosus* Stal. Reasons are given above for this change in opinion.

Paracalocoris parenthesis n sp.

Allied to *maculosus* but differs in the larger size and different color aspect; hemelytra with purple lake ground color, having two pale stripes on clavus and four stripes on the corium.

♂. Length 5.6 mm., width 2.7 mm. Head: width 1.19 mm., vertex .51 mm.; ground color reddish to purple lake beneath, above more yellowish, with six or seven transverse or slightly oblique reddish

lines each side of frons; apex and marks each side of tylus pale to whitish, the pale color invaded by fine reddish reticulations; spot above and lower margin of juga, apex and lower margin of lora, and bucculæ except narrow margin above, white; genæ with broad white stripe beneath lower margin of eye and extending along ventral margin of lora, also a small mark behind eye and the posterior surface of eyes white.

Rostrum, length 2.38 mm., just attaining posterior margins of hind coxæ, dark reddish, apex more blackish, pale at joints. Antennæ: segment I, length 1.08 mm., dark reddish brown, with several small, largely confluent, pale spots, clothed with short black pubescence; II, 2.55 mm., apical half black, basal half brown, a narrow pale band at middle (slightly distad of middle) and another placed close to the blackish base, clothed with fine, short brownish to black pubescence; III, .91 mm., blackish, with pale band at base and middle; IV, .86 mm., blackish, narrowly pale at base.

Pronotum: length 1.46 mm., width at base 2.16 mm ; ground color purple lake to dark brownish red, narrow basal margin and continuing as a line along dorsal margin of propleura, two lines on propleura of which the lower crosses middle of coxal cleft, collar, anterior and basal margins of calli, and median line on basal half of disk, white; an arcuate or parenthesis mark beginning at anterior margin of each callus and curving back to near basal margin of disk, pale to yellowish; with three or four pale to yellowish spots each side of median line on middle of disk; calli yellowish, with numerous small reticulate reddish marks. Scutellum and mesoscutum purple lake, median line, lateral margins, and obsolete line between these, pale to yellowish.

Hemelytra with ground color of purple lake, two longitudinal lines on clavus, four such lines on corium of which one follows the radius while all are more or less interrupted distally, and narrow embolar edge, pale to yellowish; narrow outer margin of cuneus, three or four spots on disk, and line separating the blackish paracuneus, pale to yellowish. Membrane fuscous to blackish, disk of areoles and small mark behind tip of cuneus, slightly paler; veins blackish, with white about apical end of larger areole. Ventral surface purple, becoming clear red on genital segment, pleura largely pale; venter marked with obliquely curving white lines. Legs purple lake to brownish red, femora with numerous small white spots, some confluent, a larger white patch on dorsal aspect of hind femora near middle of apical half; tibiæ with two rather broad pale bands, sometimes rather obscure, spines black and distinct, pubescence and hairs rather short; tarsi blackish, slightly paler at base.

Dorsum distinctly shining, clothed with fine, recumbent, pale to golden yellow pubescence, more prominent on hemelytra, with blackish pubescence on cuneus; venter pale pubescent, legs with both pale and black hairs.

♀. Length 5.7 mm., width 2.94 mm. Head: width 1.19 mm., vertex .56 mm. Antennæ: segment I, length 1.08 mm.; II, 2.42 mm.; III, .95 mm., basal half nearly white, the brown color very pale; IV,

.91 mm. Pronotum: length 1.49 mm. width at base 2.27 mm. More robust than the male but very similar in coloration and pubescence.

Holotype: ♂ June 20, 1928, alt. 6200 ft., Chiricahua Mts. Arizona (A. A. Nichol); author's collection. *Allotype:* same data as the type. *Paratypes:* 2 ♂ 3 ♀, taken with the type. ♂ July 3, 1926, alt. 7000 ft., Rincon Mts., Arizona (A. A. Nichol).

Paracalocoris fasciolus n. sp.

Allied to *parenthesis* but distinguished as shown in the key; hemelytra reddish brown and with pale stripes much as in *parenthesis* but differs otherwise in the longer first antennal segment and various color markings.

♀. Length 5.2 mm., width 2.8 mm. Head: width 1.09 mm., vertex .54 mm.; yellowish, more white beneath, marked with reddish brown lines and reticulations. Rostrum, length 2.16 mm., slightly surpassing posterior margins of hind coxæ. Antennæ: segment I, length 1.1 mm., dark reddish brown to blackish, marked with several irregular white spots, clothed with yellowish and black pubescence; II, 2.08 mm., black, with a single, very distinct white annulus situated at a point .21 mm. short of middle, more brownish than black just before the annulus; III, 1.04 mm., black, basal one-third white; IV, .86 mm., blackish, narrowly white at base, brownish on middle third. Pronotum: length 1.34 mm., width at base 2.08 mm.; yellowish brown to reddish brown, more blackish near basal angles; basal margin, median line, several large spots on basal half of disk, a large spot laterad of the black discal spots, collar, bordering anterior margins of calli, and two rather broad stripes on propleura, white. Scutellum white, tinged with yellowish, a rather broad reddish brown stripe each side of median line but scarcely attaining either base or apex. Mesoscutum only slightly exposed, reddish brown, sides whitish.

Hemelytra dark reddish brown, two longitudinal stripes on clavus, four such stripes on corium and one stripe on embolium, white, each of the stripes interrupted at one or two points; cuneus white on middle, apex black, inner basal angle and four or five spots in the dark color on basal third, whitish. Membrane dark fuscous, large spot within larger areole, center of membrane and extending in a sinuous line to outer margin behind apex of cuneus, pale; veins white, base of brachium and anal vein blackish. Ventral surface reddish brown, sternum yellowish brown, pleura largely white, venter marked with curving white lines much as in *jurgiosus*. Legs chiefly white and marked with reddish brown; basal half of femora more brownish and broken by large white spots and marks, distal half white and marked with brown, a narrow blackish annulus at middle of apical half; tibiæ annulate with reddish brown, more broadly annulate with white on middle and apex; tarsi blackish, brownish on basal half.

Dorsum distinctly shining, clothed with fine, recumbent, pale to golden yellow, partly sericeous pubescence; venter yellowish pubescent. legs pale to brownish hairs, a few stiff black bristles on femora; tibial spines blackish, only a few hairs as long as the spines.

Holotype: ♀ September 4, 1925, Santa Rita Mts., Arizona (A. A. Nichol); author's collection.

Paracalocoris virgulatus n. sp.

Allied to *parenthesis*, and having much the same color aspect, but differs in the smaller size and relatively shorter antennal segments.

♂. Length 4.3 mm., width 2.2 mm. Head: width 1.04 mm., vertex .43 mm.; yellowish to brownish but without distinct marks. Rostrum, length 1.73 mm., extending to middle of hind coxæ, brownish, apex blackish. Antennæ: segment I, length .73 mm., brown, with pale on dorsal aspect, clothed with short brownish pubescence; II, 1.66 mm., basal half brown, a narrow pale band set next to the blackish base, a distinct white annulus with its basal edge set at middle of segment and separating the black on apical half from the brown, clothed with fine, short yellowish to dusky pubescence; III, .60 mm., pale, the apical two-fifths black; IV, broken. Pronotum: length 1.14 mm., width at base 1.75 mm.; discal spots small, color pale yellowish and with brown, the pale areas much as in *parenthesis* but the arcuate marks on disk and the median line more broadly pale; propleura with three distinct pale lines. Scutellum pale yellowish, with brown stripe each side of median line but confluent on apex, also a shorter brown stripe at each side on basal half and parallel with lateral margin; the brown stripes invaded by and flecked with the pale color.

Hemelytra longitudinally striped with pale and brown; clavus pale, margins and median stripe along claval vein, dark brown; corium with four pale stripes, the second incomplete while the two outer stripes are confluent apically, the third stripe extending across inner basal angle of cuneus; embolium with brown stripe, its outer edge pale; cuneus dark reddish brown, narrow outer margin and more or less on disk pale, the paracuneus, brownish black, a pale spot on inner angle. Membrane pale fuscous brown, areoles and veins brownish black, cubital vein about apex of larger areole white. Ventral surface more yellowish than brown, sides of venter distinctly marked with alternating arcuate lines of yellow and brown. Legs light brown, irrorate and irregularly marked with pale, femora more broadly pale across middle; front tibiæ alternately biannulate with pale and brown, hind pair with a paler band at middle and with an obsolete paler band near apex; tarsi brownish, apex black.

Dorsum distinctly shining, clothed with fine, recumbent, golden to yellowish pubescence, the golden pubescence more or less sericeous on clavus and corium.

Holotype: ♂ April 26, 1916, Sabino Canyon, Santa Catalina Mts., near Tucson, Arizona (J. F. Tucker); author's collection.

Paracalocoris virgulatus stigmosus n. var.

Differs from typical *virgulatus* as indicated in the key; pronotal disk dark brown, with a straight, longitudinal pale ray beginning at outer angle of each discal spot, a triangular pale spot situated between discal spots, its apex extending half way to basal margin of disk; propleura pale or white, a slender brown line near dorsal margin and parallel to lateral edge of disk, also with a submarginal brown line bordering ventral margin. Hemelytra with more brown than *virgulatus*, corium with three incomplete pale stripes and a pale spot at outer apical angle.

♀. Length 4.8 mm., width 2.68 mm. Head: width 1.1 mm., vertex .49 mm. Rostrum, length 1.8 mm., just attaining posterior margins of hind coxæ. Antennæ: segment I, length .84 mm., brown and spotted with pale; II, 1.79 mm., basal half brown, with pale band next to the dark base and a more distinct white annulus at middle, thus separating the brown from the black apical half; III, .77 mm., pale, apical two-fifths black; IV, shriveled, black, pale at base. Pronotum: length 1.26 mm., width at base 1.95 mm.

Type: ♀ June 3, 1904, Brownsville, Texas (H. S. Barber); author's collection. *Paratype:* ♀ June 12, 1921, Eastland Co., Texas (Grace O. Wiley).

This form was originally received in exchange as *P. jurgiosus* Stal.

Paracalocoris limbus otiosus n. var

Differs from typical *limbus* McA. in having the embolium and outer margin of corium largely blackish; first antennal segment reddish brown and with yellowish spots.

♂. Length 6.6 mm., width 2.6 mm. Head: width 1.14 mm., vertex .50 mm. Rostrum, length 2.4 mm., reaching to middle of hind coxæ, blackish. Antennæ: segment I, length 1.47 mm., reddish brown and with numerous yellowish spots; II, 2.54 mm., black; III, 1.04 mm., blackish, pale to dusky on basal half; IV, 1.12 mm., black. Pronotum: length 1.38 mm., width at base 2.12 mm.

Head pale to yellowish and with black, tylus black except for yellow spot each side near apex; frons fuscous each side of median line, juga largely, bucculæ, and genæ yellowish. Dorsum chiefly blackish; collar, calli, median line of pronotal disk, slender median line on scutellum, basal angle of corium, along radial vein to middle of corium, apex of

embolium, and cuneus except apex, pale to reddish yellow. Membrane uniformly brownish black, cubital vein pale about apex of larger areole. Ventral surface blackish, a white mark across side of episternum; sides of venter with a pale line near dorsal margin and a series of spots just beneath it. Femora blackish, rather thickly marked with pale and white spots, hind pair with large pale area on middle of dorsal aspect. Tibiæ brownish black, hind pair with pale band just short of middle and a second band near apex; tarsi yellowish, apex black.

Type: ♂ July 5, Brookline, Massachusetts (C. W. Johnson); author's collection. *Paratype:* ♂, same data as type.

Paracalocoris limbus suffusus n. var.

Differs from typical *limbus* McA. at least in having the usual paler areas clouded over with dusky.

♀. Length 6.4 mm., width 2.8 mm. Head: width 1.13 mm., vertex .56 mm. Rostrum, length 2.47 mm., nearly attaining posterior margins of hind coxæ. Antennæ: segment I, length 1.47 mm., black, a few pale spots evident; II, 2.38 mm., black; III, .99 mm., black, pale at base; IV, 1.03 mm., black, pale at base. Pronotum: length 1.43 mm., width at base 2.16 mm.

Color fuscous brown to blackish, the usual paler areas clouded with dusky, corium and cuneus with a few small paler points. Scutellum dusky, to pale fuscous, slender median line paler. Ventral surface dusky to fuscous; venter distinctly paler on ventral surface, also a pale lateral line evident near dorsal margin. Legs black, coxæ pale except on base; femora with series of small white spots; tibiæ with pale bands obsolete; tarsi dusky, tips blackish.

Type: ♀ July 3, 1926, Beltsville, Maryland (H. H. Knight); author's collection.

Paracalocoris pallidulus McAtee.

1916. *Paracalocoris hawleyi* var. *pallidulus* McAtee, Ann. Ent. Soc. Am., ix, p. 380.

For some time I have regarded this species as distinct from *hawleyi* Kngt., chiefly because this particular form was never taken on hops with *hawleyi*, and again because the type and a good series of specimens were reared from apple shoots at Batavia, N. Y. Recently, upon going over my material to work out a new key, a good character for separation was found in the first antennal segment which measures consistently longer, as compared with width of head, than in specimens of *hawleyi*. The color of *pallidulus* also differs from any known form of *hawleyi*.

In the original description of *hawleyi* the writer made comparison with *colon* Say, but the specimens I took to be *colon* Say were later forwarded to Mr. McAtee and he described them as *pallidulus*. This is of interest merely to show that even when I described *hawleyi* I considered *pallidulus* a distinct species, but called it *colon* Say since it fit the description better than any species known to me at that time.

A mid-western form of *pallidulus* McA. differs in certain respects, perhaps biologically, hence a varietal name is proposed.

Paracalocoris pallidulus albigulus n. var.

Differs from *pallidulus* McA. in the paler antennæ and in the pale to whitish gula and genæ.

♂. Length 6 mm., width 2.4 mm. Head: width 1.08 mm., vertex .49 mm. Rostrum, length 2.42 mm., nearly attaining posterior margins of hind coxæ, pale yellowish, apex brownish black. Antennæ: segment I, length 1.34 mm., pale, with spots and reticulate marks of brown; II, 2.29 mm., pale yellowish to light brown, apical half more reddish brown; III, .95 mm., pale yellowish, apical half fuscous brown; IV, 1.21 mm., blackish. Pronotum: length 1.23 mm., width at base 1.9 mm.

General coloration brown, median line on pronotum and scutellum, a ray beginning at outer margin of each discal spot, a short ray near each basal angle of scutellum, along radial vein to near middle of corium, irregular spots near tip of embolium, discal area of cuneus but invaded with brown, and dorsal aspect of the head, pale; gula, genæ, and bucculæ white, also a mark across middle of juga and a spot each side near tip of tylus, pale. Discal spots brown, outer and inner margins pale. Legs pale to brownish, hind femora with more brown but thickly irrorate with white; tibiæ pale, obsoletely banded with brown.

♀. Length 6.5 mm., width 2.6 mm. Head: width 1.12 mm., vertex .52 mm. Antennæ: segment I, length 1.51 mm.; II, 2.38 mm.; III, 1.08 mm.; IV, 1.34 mm. Pronotum: length 1.34 mm., width at base 2 mm. Very similar to the male in coloration and pubescence.

Holotype: ♂ July 20, 1923, Norman County, Minnesota (A. A. Nichol); author's collection. *Allotype:* same data as the type. *Paratypes:* ♂ 3 ♀ June 20, 1922, ♀ July 14, 1923, Norman County, Minn. (A. A. Nichol). ♂ July 18, ♂ July 19, 1923, Trail County, North Dakota, (A. A. Nichol).

Paracalocoris castus McAtee.

1916. *Paracalocoris colon* var. *castus* McAtee, Ann. Ent. Soc. Am., ix, p. 382.

For some years I have believed this form must represent a distinct species, an opinion gained by collecting and observing

several hundred specimens, all of which have been found on the same host plant, woodbine or Virginia creeper (*Psedera quinquefolia* L.). At various times it has been possible to collect numerous specimens, and for the purpose of studying possible variations, I once mounted 225 specimens, taken July 14, 1924, St. Paul, Minnesota. This species varies very little if any in color pattern, although the intensity of pigment varies with the age of specimens when taken. The antennal colors are I believe very constant, and the species can always be separated from *colon* Say as shown in the key.

The varieties *colonus* McA., and *amiculus* McA., are color forms of this species. The name *castus* McA., should I believe, be selected to represent the species since it has page priority over the two other varietal names which refer to this species. Unfortunately the name *castus* was founded on teneral specimens, but that does not prevent the use of the name for the species. The varietal name *colonus* McA. applies to normally colored specimens of the species, but in this case will have little use since we do not wish to limit the typical name *castus* to teneral specimens. Varietal name *amiculus* McA. applies to the darker and strongly colored individuals of the species. In this species we do not find such remarkable color forms as occur in *scrupeus* Say and *externus* H. S., for example, hence the varietal names have less utility. The writer believes that varietal names are useful when applied to species having diverse color patterns, but not so useful when proposed for intensity of pigmentation alone. Each color pattern has a range of intensity of pigmentation, usually becoming deeper or darker with age; but the color areas, or pattern outline does not change with the individual, once the adult stage has been attained.*

Paracalocoris adustus McAtee.

1916. *Paracalocoris adustus* McAtee, Ann. Ent. Soc. Am., ix, p. 377.

The unique female type is here redescribed, chiefly to record the head measurements, characters that are critical for keying the species.

♀. Length 8 mm. Head: width 1.14 mm., vertex .54 mm. Rostrum, length 2.6 mm., nearly attaining posterior margins of hind coxæ, reddish to fuscous, apex blackish. Antennæ: segment I, length

*Knight, H. H. Ann. Ent. Soc. Am., XVII, 1924, pp. 258–272.

1.60 mm., clothed with recumbent black hairs and intermixed on anterior aspect with about fifteen erect black bristles which in length do not exceed thickness of segment, uniformly dark red without any trace of spots; II, 2.74 mm., more slender on basal half and tapering to thicker toward apex, thickly clothed with short blackish pubescence, a single erect black bristle near base, color uniformly dark red without trace of annuli; "third 1.16 mm.; fourth 1.1 mm." Pronotum: length 1.43 mm., width at base 2.12 mm.

"Color an almost uniform reddish brown, a little lighter on cuneus and lower surface and inclining to fuscous on antennæ, tibiæ and inner margin of elytra; membrane dusky. Short pale yellow hairs abundant on upper surface, except membrane."

The writer has been unable to recognize additional specimens that could be referred to this species. The type was collected at Lakehurst, New Jersey, June 13, 1908 (Wm. T. Davis) and must still be classed among that small but select group of species known only from that locality. Hussey (1922) records *Paracalocoris adustus* McA. from Berrien County, Michigan, specimens that the writer so identified at that time, but one of these specimens (July 19) is still at hand and I find it belongs to *salicis* Kngt. The writer is indebted to Mr. Wm. T. Davis for the loan of the type *adustus* for the present study. Mr. Davis remarks: "It has traveled much and is now some broken." The legs are gone and the wings except one clavus. The first two segments of one antenna are securely glued to the collection label, which is fortunate for the present study.

KEY TO THE SPECIES OF PARACALOCORIS.

1. Hind tibiae thickly clothed with long, erect hairs which obscure or become confused with the tibial spines.......... **scrupeus** Say
   Hind tibiae with hairs shorter and more appressed, especially on inner side, hairs not easily confused with the true spines.......... 2
2. Discal spots of pronotum black or marked with brown or black.......... 3
   Discal spots of pronotum yellowish or orange colored; length of antennal segment I distinctly greater than length of pronotum......**externus** H. S.
3. Antennal segment I as long as or longer than pronotum (by micrometer measurement).......... 4
   Antennal segment I shorter than length of pronotum.......... 8
4. Antennal segments I and II black or brown, but when brown or red, segment I with paler spots and segment II with paler bands 5
   Antennal segments I and II uniformly dark red, without spots or bands; coloration everywhere except discal spots and membrane, a lighter or darker reddish brown.......... **adustus** McA.
5. Antennal segment I equal to width of head plus dorsal width of an eye, or greater.......... 6
   Antennal segment I not equal to width of head plus dorsal width of an eye; length 6-6.5 mm.......... **hawleyi** Kngt.
6. Antennal segment I only equal to width of head plus dorsal width of an eye, or slightly greater.......... 7
   Antennal segment I equal to width of head plus width of vertex; pubescence uniformly silvery white.......... **johnstoni** n. sp.

7. Antennal segment II pale yellowish to brown, sometimes dark brown but never black; general coloration brownish and with pale irrorations, **pallidulus** McA.
   (a) Antennal segment I reddish brown and with pale spots; gula and genae dark brown........................variety **pallidulus** typical
   (b) Antennal segment I more pale than brown; gula and genae pale, variety **albigulus** n. var.

   Antennal segment II uniformly black..........................**limbus** McA.
   (a) Antennal segment I uniformly black; cuneus, embolium, and corium exterior to radial vein, yellowish red..........variety **limbus** typical
   (b) Antennal segment I reddish brown and with pale spots; embolium and outer apical area of corium more or less blackish, variety **otiosus** n. var.
   (c) Antennal segment I black but with pale spots; cuneus and embolium dusky, but with yellowish apparent in hypodermis, variety **suffusus** n. var.
8. Length of antennal segment I equal to or greater than width of head...... 9
   Length of antennal segment I not equal to width of head................16
9. Ground color white, in part tinged with yellow, scutellum immaculate white, cuneus white with extreme apex black, tibiae without bands, **albifacies** n. sp.
   Otherwise colored..10
10. Ground color a medium to dark shade of burnt sienna, marked with pale yellowish stripes, the longest stripe bordering radial vein and terminating at inner angle of cuneus, another one on corium paralleling the clavus..**heidemanni** Reut.
    Otherwise colored..11
11. Scutellum white or yellowish, dark color restricted to a pair of dark stripes, one each side of median line..................................12
    Scutellum dark, usually with pale median line; sometimes largely pale but without a pair of distinct dark stripes on a pale ground.............13
12. Dorsum pale to yellowish, the dark color broken by many rounded pale spots, thus forming numerous blackish reticulations; venter uniformly yellowish...**marmoratus** Uhl.
    Dorsum dark reddish brown, hemelytra with longitudinal pale stripes, rounded spots scarcely evident except on pronotal disk; venter alternately marked with curving white and dark brown stripes, **fasciolus** n. sp.
13. Antennal segment II uniformly yellowish brown, or blackish only on apical half...14
    Antennal segment II dark brownish black to black, sometimes with an obsolete pale band at middle; scutellum with distinct pale median line.. .**severini** Kngt.
    (a) Hemelytra and pronotum uniformly light reddish, a few lighter maculae evident.......... ....variety **severini** typical
    (b) Hemelytra and pronotum light reddish brown, with numerous small paler maculae evident................variety **modestus** Kngt.
    (c) Clavus and inner half of corium dark fuscous to blackish, variety **nigriclavus** Kngt.
14. Pronotum and scutellum not distinctly trivittate; first antennal segment pale and marked with brown, or brown and with pale.................15
    Pronotum and scutellum distinctly trivittate with pale; first antennal segment black, with few if any pale spots..............**trivittis** Kngt.
15. Antennal segment II with apical half black or brownish black; scutellum with narrow median pale line, sometimes obscured by brownish tinge..**evonymi** n. sp.
    Antennal segment II rather uniformly yellowish brown, in darkest specimens with blackish only on apex; scutellum with pale color irregularly distributed, the brown color largely broken by pale irrorations, **salicis** Kngt.

16. (8) Ground color white to pale greenish yellow, scutellum uniformly white, sometimes invaded by black at middle of base; cuneus pale to orange colored.. **deleticus** Reut.
Otherwise colored.. 17
17. Ground color a light burnt sienna, radial vein bordered by a pale yellow stripe which terminates at inner angle of cuneus.......... **breviatus** Kngt.
Otherwise colored.. 18
18. Venter marked with prominent, obliquely curving white arcs; dorsum distinctly shining, clothed with very fine short pubescence.............. 25
Venter, if marked, having only a few pale dashes near dorsal margin; dorsum not distinctly shining, strongly pubescent.................... 19
19. Dorsum chiefly light red to madder brown, leaving numerous small pale irrorations, embolium pale except apex; antennal segment II uniformly blackish, sometimes with pale annulus just before middle, **nicholi** Kngt.
Otherwise colored.. 20
20. Ground color dark brown, the paler color taking the form of fine lines and small dots.. 22
Ground color light, sometimes dark brown, but in that case the dorsum mottled with several large yellowish patches.......................... 21
21. Antennal segment II not equal to width of pronotum at base; ground color yellowish to greenish, the darker color forming in large cloud-like patches on the dorsum.................................. **floridanus** Kngt.
Length of antennal segment II exceeding width of pronotum at base; ground color of the dorsum dark brown, mottled with several large yellow patches, one on apical half of scutellum, apex of clavus, middle of corium, apex of embolium and outer half of corium, and three areas on pronotum.................................. **multisignatus** Reut.
22. Antennal segment II with a narrow white annulus near middle which separates the black on apical half from the brownish basal half........ 23
Antennal segment II yellowish brown on basal half but without narrow white annulus at middle or base.................................. **castus** McA.
23. Rostrum extending beyond hind coxae.................... **celtidis** n. sp.
Rostrum not extending beyond hind coxae.............................. 24
24. Antennal segment II dark, with pale annulus only at middle; femora dark at base, apical half with one large and several smaller white spots, **gleditsiae** Kngt.
Antennal segment II with pale annulus next to the black base and likewise at middle; femora broadly pale on base and middle. ..... **colon** Say
25. (18) Pronotal disk with two pale rays each side of the pale median line; corium with two pale rays, confluent apically where the corium is transversely pale; cuneus pale with black spot only at inner basal angle and at extreme apex.................................. **jurgiosus** Stal
Otherwise colored.. 26
26. Clavus and corium with longitudinal pale stripes, with but few small spots.. 27
Clavus and corium with series of small pale spots, corium with short pale stripe at basal angle, also along base of radius, but apical half of corium with pale spots only.................................. **maculosus** n. sp.
27. Antennal segment II, in length, greater than basal width of pronotum; pronotal disk with a pair of pale parenthesis marks enclosing the discal spots and basal half of disk; length 5.6–6 mm.......... **parenthesis** n. sp.
Antennal segment II, in length, not equal to basal width of pronotum, **virgulatus** n. sp.
(a) Pronotal disk with arcuate pale mark at each side, enclosing discal spots and central area of disk as with parenthesis marks, variety **virgulatus** typical
(b) Pronotal disk without arcuate marks, the pale marks taking the form of straight rays.................. variety **stigmosus** n. var.

BOOK NOTICES.

THE PLANT QUARANTINE AND CONTROL ADMINISTRATION. By GUSTAVUS A. WEBER. Pages I–X and 1–198. Service Monograph of the United States Government, No. 59. Published by The Brookings Institution, Washington, 1930.

This is a volume for students of quarantine administration and is a companion volume to No. 60, The Bureau of Entomology. Part I, History, pp. 1–92, gives a brief history of plant quarantine in the United States and adjacent territories. Part II, Activities, pp. 93–121, covers the projects which are being handled at present, while Part III, Organization, lists and discusses the work by Divisions. The volume closes with six Appendices including laws, a list of official positions with salaries, bibliography, financial statement, etc. This appears to be a meatier volume than No. 60 and brings together widely scattered data that will be of interest to economically minded applied entomologists. It is in a way unfortunate that these volumes have had to be written from such an impersonal point of view, with no mention of leaders in the work. Some of the ablest men in entomology have been associated with this service and have given of their best in these front-line battles.

C. H. K.

BLATCHLEYANA, A LIST OF THE PUBLISHED WRITINGS OF W. S. BLATCHLEY * * * TOGETHER WITH A CHRONOLOGY OF HIS LIFE: THE FIXATION OF TYPES OF NEW GENERA AND SPECIES DESCRIBED BY HIM, ETC. Pages 1-77 with two portraits. Published by The Nature Publishing Co., Indianapolis, 1930.

The contents of this little volume are indicated by the title. It is the type of publication of which students would appreciate more. The few lists of this kind usually complied by somebody other than the author have been found very useful. After working for days in a library compiling the titles of an author, one wishes that he had been as thoughtful for posterity as has Doctor Blatchley. The reviewer has attempted to solve this problem by sending with reprints to specialists a mimeographed list of his writings which gives the specialist a check on his card index. He has also had the experience of having worked up more complete lists than the author himself had in his records. Blatchleyana lists 197 books and articles, 376 new species and varieties of Coleoptera, 66 new species of Heteroptera and 29 new species of Orthoptera. It is beautifully printed with interesting quotations scattered through it from Blatchley's own writings which frequently convey a feeling of the isolation of a research mind in this social world. The book is obviously written by Blatchley himself though no authorship is given.—C. H. K.

INDEX TO VOLUME XXIII.

DATES OF ISSUE FOR VOLUME XXIII.

March Number—March 21, 1930.
June Number—June 28, 1930.
September Number—October 18, 1930.
December Number—December 26, 1930.

The Entomological Society of America

CONSTITUTION.

(As amended to date, January 1, 1930.)

ARTICLE I.

NAME.

SECTION 1. This organization shall be known as The Entomological Society of America.

ARTICLE II.

OBJECT.

SECTION 1. It shall be the purpose of this Society to promote the science of entomology in all its branches, to secure cooperation in all measures tending to that end, and to facilitate personal intercourse between entomologists.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The membership of this Society shall consist of three classes: members, fellows and honorary fellows.

SEC. 2. All persons interested in entomology shall be eligible to membership.

SEC. 3. Members who have made important contributions to the science of entomology may be elected fellows or honorary fellows of the Society.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of this Society shall be a President, two Vice-Presidents, a Secretary and a Treasurer, but these two last offices may be held by the same person.

SEC. 2. Executive Committee.—The business of the Society not otherwise provided for shall be in the hands of an Executive Committee, consisting of the Officers named in Section 1, and six additional members, five of whom shall be elected from the Fellows of the Society, and the sixth shall be ex-officio the Managing Editor. There shall be a meeting of the Executive Committee at each Annual Meeting. Four members shall constitute a quorum and in the case of the non-attendance of this number at any Annual Meeting, the Society shall elect a sufficient number from among the Fellows in attendance to complete the quorum.

SEC. 3. Councillors to the American Association.—Two representatives on the Council of the American Association for the Advancement of Science shall be elected by ballot at the Annual Meeting for a term of one year, and shall be eligible for re-election. In case of the death, resignation, absence or inability to serve of either or both councillors, the vacancy shall be filled by the Executive Committee.

Article V.

ELECTIONS.

Section 1. Election of Members.—Nominations for membership may be made by any two members, and election shall be by the Executive Committee.

Sec. 2. Election of Fellows.—All nominations for fellows shall be signed by three or more fellows and each nomination shall be accompanied by the following information concerning the nominee: Name, address, occupation, branches of entomology engaged in, positions held involving entomological experience, entomological work done, and list of more important publications. Election shall be by ballot by the Executive Committee, a majority vote of the Committee being necessary for election.

Sec. 3. Election of Officers.—All officers shall be elected by ballot at the Annual Meeting for the term of one year and shall be eligible for re-election.

Sec. 4. Election of Honorary Fellows.—Honorary Fellows may be nominated by unanmious vote of the members of the Executive Committee present at an annual meeting. The nominee shall be voted on by the members by ballot, and must receive four-fifths of all ballots cast to be elected. Not more than one Honorary Fellow may be elected in three successive annual meetings.

Article VI.

MEETINGS.

Section 1. An annual meeting shall be held in affiliation with the American Association for the Advancement of Science, or at such time and place as the Executive Committee may select.

Article VII.

PUBLICATION.

Section 1. Publication.—The official publication of the Society shall be known as the Annals of the Entomological Society of America. Each volume shall consist of four fascicles and the first fascicle of each volume shall contain the proceedings of the Annual Meeting.

Sec. 2. Editorial Board.—The publication shall be under the charge of an Editorial Board consisting of ten members, one of whom shall be the Managing Editor. The Managing Editor and his associates shall be responsible for the selection of material to be published.

Sec. 2. Election of Editorial Board.—The members of the Editorial Board shall be elected by the Executive Committee. Each member of this Board, excepting the Managing Editor, shall serve for three years or until his successsor has been elected, three members retiring annually.

Sec. 4. Report of Managing Editor.—The Managing Editor shall present a report at each Annual Meeting to the Executive Committee and the accounts of his office shall be reported upon by the Auditing Committee.

Article VIII.

THOMAS SAY FOUNDATION.

Section 1. Name.—There is hereby established a standing committee of the Society under the name of "The Thomas Say Foundation."

Sec. 2. Purpose.—The purpose of this Foundation is for the publication of the works of a monographic or bibliographic character on the insects of North America.

Sec. 3. Publication.—Each publication shall be a volume complete in itself, and numbered consecutively.

SEC. 4. Committee.—This committee shall consist of six members, four of them to be elected by the Executive Committee of the Society, two of them retiring annually, and an Editor and a Treasurer to be designated by the Executive Committee.

SEC. 5. Powers.—This Committee is empowered to determine all matters concerning the publication.

SEC. 6. Funds.—They are also empowered to solicit, hold, invest, and expend funds committed to their care; only the interest of any endowment to be available.

SEC. 7. Responsibility.—The Society shall be in no way responsible for debts contracted by this Foundation, unless previously authorized by the Executive Committee.

SEC. 8. Reports.—The Editor and Treasurer shall present a report of their operations and expenditures to the Executive Committee at each Annual Meeting, and the accounts of the Treasurer shall be audited by the Auditing Committee of the Society. These reports shall be published as a part of the proceedings of the Executive Committee of each Annual Meeting.

ARTICLE IX.

AMENDMENTS.

SECTION 1. This constitution may be altered or amended at any annual meeting by a two-thirds vote of the members present, a copy of each amendment proposed having been presented at the previous annual meeting.

BY-LAWS.

1. The annual dues for members and fellows shall be three dollars.

2. A majority of the members present at an annual meeting shall constitute a quorum for the transaction of business.

3. Notice of all meetings of the society shall be sent to all members at least one month in advance.

4. The Executive Committee shall provide a program for all meetings, including at the annual meeting a popular lecture and a technical entomological exhibit of materials and methods.

5. The time of the business shall be published prior to the opening session of the annual meeting.

6. Any member may become a life member upon payment of $50.00 at one time, and shall be exempt from further assessment. He shall receive during his life, one copy of each issue of the Annals.

7. Members two years in arrears shall be dropped from the rolls by the secretary after twenty days notice.

8. A member elected shall not be in good standing until he pays his first years dues. In case he shall not have made such payment at the expiration of one year from the date of election, he shall be dropped from the roll by the secretary after twenty days notice.

9. The Annals of the Entomological Society of America will not be mailed to any fellow or member whose dues are in arrears. All dues are payable December 1, and should be received not later than March 1.

LIST OF MEMBERS
Entomological Society of America

In this list, which is arranged alphabetically, members are given in lower case type, Fellows in small caps and Honorary Fellows in capitals. The year of admission to membership is given before the name, and of election to Fellowship and Honorary Fellowship in parentheses following the address. Names of Life Members are indicated by asterisk (*) and the special field of work in italics. Ch. indicates Charter Member, 1906.

'26. Abbott, Cyril E., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Behavior.*
'28. Adams, Chas. F., State Bd. Health, Indianapolis, Ind. (F. '29). *Mycetophilidæ.*
'28. Adkins, T. R., 801 Smith Young Tower, San Antonio, Texas.
'08. Ainslee, C. N., 2000 S. St. Aubin Street, Sioux City, Iowa. *Hymenoptera.*
Ch. *Aldrich, J. M., National Museum, Washington, D. C. (F. '07). *Diptera.*
'10. Alexander, C. P., Mass. Agr. College, Amherst, Mass. (F. '07). *Tipulidæ.*
'13. Allee, W. C., Zool. Bldg., Univ. of Chicago, Chicago, Ill. *Behavior.*
'26. Allen, H. W., Jap. Beetle Lab., Moorestown, New Jersey. *Tachinidæ.*
'30. Anderson, Edwin J., Agr. Exp. Sta., State College, Pa.
'29. Anderson, L. D., 1621 Edgehill Road, Lawrence, Kansas.
'26. Andrews, Arthur W., 133 Tyler Ave., Detroit, Mich. *Coleoptera.*
'28. App, Bernard A., 67 N. Liberty Street, Elgin, Ill.
'23. Armstrong, Thomas, Ent. Lab., Vineland Sta., Ontario. *Scarabaeidæ.*
'22. Arnold, Geo. F., State Plant Bd., A. & M. College, Miss. *Cerambycidæ.*
'26. Atkinson, Norman J., State Nat. Hist. Survey, Urbana, Ill. *Noctuidæ.*
'29. Atwell, H. C., 101 Court House, Portland, Oregon.
'29. Audant, Andre, Dept. Ent., State Agr. College, Manhattan, Kan. *Cotton Ins.*

'18. Babcock, O. G., Box 407, Sonora, Texas. *Mallophaga, Anoplura.*
'26. Babiy, Paul P., Dept. Ent., Cornell Univ., Ithaca, N. Y. *Hymenoptera.*
'22. Baerg, W. J., Univ. Ark., Fayetteville, Ark. *Poisonous Anthropods.*
'30. Bailey, J. W., Box 107, Univ. Richmond, Richmond, Va. *Myriopoda.*
'19. Baird, A. B., 228 Dundas Street, E. Belleville, Ontario. *Parasitic Hymenoptera.*
'11. Baker, A. C., Bur. Ent., Washington, D. C. (F. '29). *Aphididæ, Aleyrodidæ*
'12. Baker, A. W., Ontario Agr. College, Guelph, Canada. *Mallophaga.*
'22. Baker, Howard, Box 1715, Shreveport, La. *Pecan Insects.*
'28. Baker, W. L., Dept. Zool., Univ. of Minn., Minneapolis, Minn.
'28. Balch, Reginald E., Forest Insect Field Station, Coeur D'Alene, Idaho.
'19. Balduf, W. V., 610 Michigan Ave., Urbana, Ill. *Chalcidoidea, Decatoma.*
Ch. *Ball, E. D., Univ.of Ariz., Tuscon, Ariz. (F. '08). *Cicadellidæ, Membracidæ, Fulgoridæ.*
'26. Ballou, Chas. A., Jr., Eton Hall, Belmoy Rd., Scarsdale, N. Y. *Coleoptera.*
'22. Banghart, Joseph, 934 Hollister St., Olney, Ill. *Lepidoptera, Coleoptera.*
Ch. Banks, C. S., 1411 Leveriza, Malate, Manila, P. I. *Diptera, Hemiptera.*
'08. Banks, Nathan, Mus. Comp. Zool., Cambridge, Mass. (F. '14).
Ch. Barber, H. G., 143 E. Third Ave., Roselle, N. J. *Hemiptera.*
Ch. Barber, H. S., U. S. National Museum, Washington, D. C. (F. '28). *Lampyridæ.*
'23. Bare, C. O., Box 1525, Sanford, Fla. *Notonectidæ, Parasitic Hymenoptera.*
'29. Bare, O. S., 1535 N. 32nd St., Lincoln, Neb. *Formicidæ, Carabidæ.*
Ch. Barlow, John, State College, Kingston, Rhode Island.
'27. Barnes, H. F., Rothamsted Exp. Sta., Harpenden, Herts., Eng. *Cecidomyidæ.*
'28. Barnes, O. L., U. S. Entomological Labr'y, Tempe, Ariz.

'28. Barrett, R. E., Box 171, Saticoy, Calif. *Coleoptera.*
'22. Bartley, H. N., 22 Elizabeth Street, So. Norwalk, Conn.
'18. Basinger, A. J., Citrus Exp. Sta., Riverside, Calif. *Citrus Insects.*
'22. Batchelder, Chas. H., 170 Beech Ave., Melrose, Mass. *Insect Pathology.*
'24. Beamer, Raymond H., 1000 Missouri Street, Lawrence, Kan. *Cicadidæ.*
'29. Bedard, Wm. D., 334 Clairmonte Ave., Syracuse, N. Y.
'20. Bedford, Hugh W., Khartoum, Sudan, Africa.
'24. Beebe, Wm., 33 W. 67th Street, New York, N. Y.
'26. Bell, Ernest L., 438 Amity Street, Flushing, N. Y. *Hesperiidæ.*
'30. Bell, Horace E., c/o University Store Co., Orono, Maine.
'26. Belon, Fernando, Apartado 133, Arequipa, Peru, South America.
'15. Benjamin, Foster H., Box 2080, Orlando, Florida. *Lepidoptera.*
'30. Benkert, Lysbeth H., Dept. Zool., Univ. of Pittsburgh, Pittsburgh, Pa.
Ch. Bentley, G. M., 406 Morrill Hall, Univ. of Tenn., Knoxville, Tenn.
'23. Benton, Curtis, Box 495, W. Lafayette, Ind. *Ecology.*
'17. *Bequeart, J. C., Harvard Med. Sch., Boston, Mass. *Hymenopt., Dipt.*
'09. Berger, E. W., St. Plant Board, Gainesville, Fla. *Coccidæ, Aleyrodidæ.*
'29. Berland, Lucien, 45 Rue De Buffon, Paris, V^e, Fr. *Arachnaidæ, Hymenopt.*
'28. Berley, J. A., Div. Ent., Clemson College, S. Car. *Coccidæ.*
'28. Berryhill, Ira W., U. S. D. A., McAllen, Texas.
Ch. BETHUNE, CHARLES J. S., 16 Washington Ave., Toronto, Canada. (F. '06, HF. '14).
Ch. Betten, Cornelius, 3 The Circle, Ithaca, N. Y. *Trichoptera.*
Ch. BEUTENMULLER, WM., 85 Elm Street, Tenafly, N. J. (F. '08). *Cynipidæ.*
'28. Bibby, F. F., Div. of Ent., College Station, Texas.
'28. Bieberdorf, G. A., A. & M. College, Dept. Ent., Stillwater, Okla. *Aphididæ.*
'26. Bigger, J. H., 1114 S. Main St., Jacksonville, Ill.
'13. Bilsing, S. W., College Station, Texas. *Cerambycidæ, Acrididæ.*
Ch. Bird, Henry, 600 Milton Road, Rye, N. Y. *Noctuidæ.*
'27. Bird, R. D., Dept. Zoo., Univ. Okla., Norman, Okla. *Tenthredinoidea.*
Ch. BISHOP, F. C., Bur. Ent., Washington, D. C.(F. '28). *External parasites.*
'24. Bishop, S. C., Dept. Biol., Univ. Rochester, Rochester, N. Y. *Arachnidæ.*
'26. Bissell, Theo. L., Experiment, Georgia. *Aphididæ.*
·'13. Blackman, M. W., State College, Forestry, Syracuse, N. Y. *Timber beetles.*
Ch. BLAISDELL, F. E., Acad. Sci., G. Gate Park, San Francisco, Cal. (F. '25). *Tenebrionidæ, Melyridæ.*
'28. Blanchard, Ralph A., 600—26th Street, Sacramento, Calif. *Homoptera.*
'26. BLATCHLEY, W. S., 1558 Park Ave., Indianapolis, Ind. (F. '27). *Coleoptera, Orthoptera, Heteroptera.*
'28. Blauvelt, Wm. E., 214 Thurston Ave., Ithaca, N. Y.
'29. Boesel, M. W., Dept. Zool., Miami University, Oxford. Ohio. *Chironomidæ.*
'26. Bolster, Percy G., 217 Norfolk St., Dorchester Center, Boston, Mass.
'26. Booth, O. E., 907 Clinton Ave., Des Moines, Iowa.
'28. Borror, D. J., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Odonata.*
'14. BÖVING, A. C., U. S. Nat. Mus., Washington, D. C. (F. '29). *Coleopterous larvæ.*
'24. Bowe, Martin, 27 Gladstone St., Providence, R. I. *Coleoptera.*
'29. Bowen, Nylos F., 441 N. 5th East, Logan, Utah.
'17. Bowers, H. L., 31 N. Eastfield Ave., Trenton, New Jersey.
'19. Bradley, George H., Mound, La. *Diptera.*
Ch. BRADLEY, J. C., Cornell, Ithaca, N. Y.. (F. '14). *Vespidæ, Scoliidæ.*
'12. Branch, Hazel E., 3756 E. Douglas Ave., Wichita, Kan. *Chironomidæ.*
'26. Brandhorst, Carl T., Breman, Kansas.
Ch. BRAUN, ANNETTE F., 2702 May St., Cincinnati, Ohio. (F. '25). *Microleptidopt.*
'27. Breakey, E. P., 125 Brittingham Place, Madison, Wis. *Fulgorida.*
'29. Brindley, T. A., Sci. Bldg., State College, Ames, Ia. *Ins. Nutrition.*
'27. Brittain, W. H., McDonald College P. O., Quebec, Canada. *Homoptera.*
Ch. BRITTON, W. E., Agr. Exp. Sta., New Haven, Conn. (F. '14). *Aleyrodidæ, Coccidæ.*
'28. Brody, Arthur L., Dept. Ent., Cornell Univ., Ithaca, N. Y.
'19. Bromley, S. W., Bartlett Tree Res. Lab., Stamford, Conn. *Asilidæ.*

Ch. Brooks, Fred E., French Creek, West Va. *Fruit and Nut Insects.*
'28. Brown, F. Martin, Avon College, Avon, Conn. *Piesidæ.*
'26. Brown, W. J., Ent. Branch, Dom. Dept. Agr., Ottawa, Can. *Coleoptera.*
'28. Bruce, Wesley G., State College Station, Fargo, North Dakota.
Ch. BRUES, C. T., Bussey Inst., Boston 30, Mass. (F. '14). *Hymenoptera.*
'30. Bruner, S. C., Estacion Exptl. Agr., Santiago de las Vegas, Havana, Cuba.
Ch. BRUNER, LAWRENCE, 3033 Deakin St., Berkeley, Cal. (F. '07). *Orthopt.*
'28. Brunson, M., Picayune, Miss.
'28. Brunson, M. H., Box H., Moorestown, New Jersey. *Truck Insects.*
'19. Bryan, Edwin H., Jr., Bishop Mus., Honolulu, Hawaii. *Diptera.*
'30. Bryant, Owen, Banff, Alberta, Canada.
'23. Bryson, H. R., Dept. Ent., Agr. College, Manhattan, Kan. *Elateridæ.*
'28. Buckell, Edw. D., Ent. Lab., Box 308, Vernon, Brit. Col., Canada. *Orthoptera.*
'22. Bulger, Jacob W., Bur. of Ent., Washington, D. C. *Physiology.*
Ch. BURGESS, A. F., 964 Main St., Melrose Highlands, Mass. (F. '17). *Carabidæ.*
'28. Burrell, R. W., 70 Groveland St., Arlington, Mass. *Parasitoid Ins.*
'28. Burris, T. H., R. D. 10, Ballinger, Texas. *Ichneumonidæ.*
'29. Bushey, C. J., Olivet College, Olivet, Ill. *Chrysochus.*
'29. Butcher, Fred D., Extension Service, Iowa Agr. College, Ames, Ia.
'28. Butler, H. G., 2303 W. Douglas Ave., Wichita, Kansas.
'19. Buys, John L., St. Lawrence Univ., Canton, N. Y. *Cicadellidæ.*
'24. Byers, C. F., Dept. Biol., Univ. of Fla., Gainesville, Fla. *Odonata.*

'12. CAESAR, LAWSON, Ont. Agr. College, Guelph, Ont., Canada. (F. '17).
'26. Caffrey, Donald J., 10 Court Street, Arlington, Mass.
'30. Caler, Horace L., Box 12, Addison, Maine.
Ch. CALVERT, P. P., Zool. Lab., Univ. of Pa., Phila., Pa. (F. '07). *Odonata.*
'24. Camacho, Carlos, Casilla 1248, Santiago, Chile.
'28. Campbell, Frank L., Bur. Entomology, Washington, D. C. *Toxicology.*
'13. Campbell, Roy E., Box 297, Alhambra, Calif. *Syrphidæ.*
'14. *Capp, S. B., Box 2054, Philadelphia, Pa.
'15. Carnochan, Frederic G., New City, Rockland Co., N. Y. *Coleoptera.*
'26. Carpentier, Fritz, Inst. Ed. Van Beneden, 10 Rue Vivegnis, Liege, Belgium. *Morphology.*
'22. Carter, Walter, Pineapple Exp. Sta., Univ. Hawaii, Honolulu, H. I. *Sphecoidea.*
'27. Cartwright, Oscar L., Box 796, Florence, South Carolina. *Cicindelidæ.*
'17. Cartwright, W. B., 600—26th Street, Sacramento, Calif.
'28. Cassidy, Thomas B., Box 1896, Tucson, Arizona.
'24. Cassino, S. E., 20 Naples Road, Salem, Mass. *Geometridæ.*
'18. CAUDELL, A. N., U. S. Nat. Mus., Washington, D. C. (F. '28). *Orthoptera.*
'29. Cecil, Rodney, Agr. Exp. Station, Geneva, N. Y.
'29. Cendana, S. M., Agr. College, Laguna, P. I.
'29. Cerny, Louis F., 1001 West Hills Pky., Lawrence, Kansas.
'14. Chaffee, Mrs. Gertrude B., Amenia, North Dakota. *Collembola.*
'24. Chamberlain, K. F., 17 S. Hawk Street, Albany, N. Y. *Gyrinidæ.*
'22. Chamberlin, Joseph C., Box 2452, Stanford Univ., Cal. *Coccidæ.*
Ch. CHAMBERLIN, R. V., Univ. of Utah, Salt Lake City, Utah. (F. '17). *Arachnida, Myriopoda.*
'17. Chambers, E. L., Office of State Entomologist, Madison, Wis.
'14. Champion, H. G., Forest Research Inst., Dehra Dun, U. P. India. *Coleopt.*
'21. Chandler, S. C., Route 5, Carbondale, Ill.
'28. Chapman, Andrew J., Tallulah, La.
'15. Chapman, J. W., Silliman Institute, Dumaguete, Negros, Philippine Isls.
'14. CHAPMAN, ROYAL N., Univ. of Hawaii, Honolulu, H. I. (F. '28). *Ecology.*
'17. Chermock, H. L., 1308 Tell St., N. S., Pittsburgh, Pa. *Lepidopt., Coleopt.*
'13. Childs, Leroy, Hood River, Oregon.
'29. Christensen, John F., Wellsville, Utah.
'30. Christenson, L. D., Central Baragua, Camaguey, Cuba.
'26. Chu, Yvanting T., St. Johns Univ., Shanghai, China. *Plecoptera.*
'18. CLAASSEN, P. W., Cornell Univ., Ithaca, N. Y. (F. '29). *Plecoptera.*

'28. Clagg, C. F., Fernald Hall, Agr. College, Amherst, Mass. *Mecopt., Hemipt.*
'23. Clark, S. W., Box 548, Weslaco, Texas.
'27. Clarke, L. Floyd, Newton, Utah.
'14. Clausen, Curtis P., Bur. Ent., Washington, D. C. *Insect Parasites.*
'26. Cleveland, C. R., c/o Standard Oil Co., 910 So. Mich. Ave., Chicago, Ill.
'17. Coad, B. R., Tallulah, La.
'07. COCKERELL, T. D. A., 908 Tenth St., Boulder, Colo. (F. '08). *Bees, Fossil Ins.*
'28. Cole, Arthur C., Jr., 2607 Glen Echo Drive, Columbus, Ohio. *Coleoptera.*
'16. Cole, Frank R., 724 Earlham Dr., Whittier, Cal. *Hymenopt., Dipt.*
'27. Coleman, L. V., 4 W. Underwood St., Chevy Chase, Md. *Sense Organs.*
'16. Collins, C. W., Gipsy Moth Labr'y, Melrose Highlands, Mass. *Calosoma.*
'29. Collins, D. L., Bussey Inst., Boston 30, Mass. *Coleopt., Tortricidæ.*
'21. Colman, Wallace, R. D. 1, Silver Springs, Maryland. *Diptera.*
'21. Compton, C. C., 614 S. State Rd., Arlington Heights, Ill. *Greenhouse & Truck Ins.*
Ch. COMSTOCK, JOHN HENRY, 123 Roberts Place, Ithaca, N. Y. (F. '06; H. F. '14).
'29. Conklin, James G., Dept. Ent., Ohio State Univ., Columbus, Ohio.
Ch. Cook, Mel T., Insular Exp. Sta., Rio Piedras, P. R. *Entomogenous Fungi.*
'19. Cook, William C., Montana State College, Bozeman, Mont. *Noctuidæ.*
'10. COOLEY, R. A., State College, Bozeman, Mont. (F. '25). *Ixodidæ.*
'21. Costa-Lima, Angelo da., Casa Luiz de Rezende-Rua do Ouvidor 116, Rio de Janeiro, Brazil. *Chermidæ.*
'15. Cotton, Richard T., Bur. Ent., Washington, D. C. *Curculionid Larvæ.*
'28. Craig, F. W, 1605 Quarrior Street, Charleston, W. Va. *Cicadellidæ.*
'11. *CRAMPTON, GUY C., 86 Pleasant St., Amherst, Mass. (F. '17). *Morphology.*
'12. Creel, Cecil W., Univ. of Nevada, Reno, Nevada.
Ch. CRESSON, E. T., JR., 11 Amherst Ave., Swarthmore, Pa. (F. '25). *Ephydridæ, Micropezidæ.*
Ch. Criddle, Norman, Treesbank, Manitoba, Canada. *Orthoptera.*
'28. Crooks, Clarence A., Box 976, Sandusky, Ohio.
Ch. CROSBY, C. R., Roberts Hall, Ithaca, N. Y. (F. '29). *Arachnida.*
'14. Crossman, S. S., Drawer B., Melrose Highlands, Mass. *Parasitic Hymenopt.*
'28. Crumb, S. E., Box 233, Puyallup, Washington.
'15. Curran, C. H., Amer. Mus. Nat. Hist., New York, N. Y. *Diptera.*
'29. Custer, C. P., Univ. Hospital, Iowa City, Iowa. *Coelioxys.*
'21. Cutright, C. R., Ohio Agr. Exp. Sta., Wooster, Ohio. *Aphididæ.*

'29. Darley, Merrill M., 473 Fourth Ave., Salt Lake City, Utah.
'26. Darlington, P. J., Jr., Mus. Comp. Zool., Cambridge, Mass. *Coleopt., Adephaga and Aquatic.*
'13. Davidson, W. M., R. D. 1, Silver Springs, Maryland.
'28. Davis, A. C., Box 35, Santa Ana, Cal. *Rhyncophora.*
'27. Davis, Cecil N., Bethany, Missouri.
'22. Davis, Edgar W., Box 342, Richfield, Utah. *Cicadellidæ.*
Ch. DAVIS JOHN J., Purdue Univ., Lafayette, Ind. (F. '17). *Aphididæ, Lachnosterna.*
Ch. *DAVIS, WM. T., 146 Stuyv. Place, Staten Isl., N. Y. (F. '17). *Cicadidæ, Orthoptera.*
'13. DEAN, GEORGE A., Kansas State Agr. College, Manhattan, Kan. (F. '17).
'26. Deay, H. O., Dept. Ent, Purdue Univ., Lafayette, Ind. *Coreidæ, Micronecta, Tenagobia.*
'24. Decker, Geo. C., Dept. Ent., State College, Ames, Ia. *Stalk Borers.*
'24. DeCoursey, R. M., Conn. Agr. College, Storrs, Conn. *Hemiptera.*
'28. DeGant, Frank D., 3401 Wade Ave., Cleveland, Ohio. *Ichneumonoidea.*
'17. DeGarnett, R. T., 135 Arbor Drive, Piedmont, Cal. *Buprestidæ Cicadellidæ, Carabidæ.*
'14. DeGryse, Joseph J., Ent. Branch, Dept. Agr., Ottawa, Canada.
'29. DeKleine, E. H., 201 I Tilden Gardens, Apt. 3000, Tilden Street, N. W., Washington, D. C.
'29. DeLeon, Donald, Forest Insect Sta., Coeur D'Alene, Id. *Scolytidæ.*
'14. DeLong, D. M., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Cicadellidæ.*

'19. Detwiler, J. D., Dept. Zool., Univ. of Western Ontario, London, Ontario.
'28. Dicke, F. F., Box 592, Charlottesville, Va.
'22. Dietrich, Henry, State Plant Board, Lucedale, Miss. *Coleoptera.*
Ch. Dietz, Wm. G., 21 N. Vine Street, Hazelton, Pa. *Tipulidæ.*
'24. Dills, Leslie E., 611 E. Seneca, Ithaca, N. Y.
'26. Dirks, C. O., Dept. Biology, Univ. of Maine, Orono, Maine.
'28. *Doak, K. D., Purdue Univ. Agr. Exp. Sta., Lafayette, Ind. *Gelechiidæ.*
Ch. DOANE, R. W., Stanford Univ., Calif. (F. '25).
'28. Dobbins T. Norman, Montrose, Miss.
'29. Dobroscky, Irene D., Boyce Thompson Inst., Yonkers, N. Y. *Cicadellidæ.*
'28. Dodd, Fred O., R. D. 5, Paris, Ill.
'22. Doering, Kathleen C., 1214 Tenn. Street, Lawrence, Kansas. *Cercopidæ.*
'22. Dohanian, S. M., 42 Cedar St., West Somerville, Mass. *Parasitic Hymenoptera.*
'28. Doner, Melvin H., Dept. Ent., Univ. of Wis., Madison, Wis. *Lepidoptera.*
'29. Dorst, Howard E., 925 Indiana St., Lawrence, Kan. *Cicadellidæ.*
'22. Doucette, Chas. F., Box 566, Sumner, Wash. *Greenhouse Ins.*
'28. Wm. A. Douglas, Cut Off, La. *Sugar cane and rice ins.*
'23. Douglass, J. R., Box 353, Estancia, New Mexico. *Chrysomelidæ.*
'28. Douglass, Nelson L., Box 613, Grenada, Miss.
'28. Dove, W. E., Box 208, Dallas, Texas. *Animal parasites.*
'28. Dove, Walter H., 518 Brightwood Ave., Dayton, Ohio. *Coccidæ.*
'22. Dowden, Philip B., Kay utca 21, Budapest II, Hungary. *Parasitic Hymenopt.*
'28. Dowdle, Verda, Utah Agr. College, Logan, Utah.
'17. Dowell, Philip, 86 Bond St., Port Richmond, Staten Is., N. Y.
'26. Dozier, H. L., Service Technique, Port-au-Prince, Haiti. *Homoptera.*
'22. Drake, Carl J., Iowa State College, Ames, Iowa. *Tingitidæ.*
'25. Duffy, Leo F., Arlington, Vt.
'26. Dunavan, David, Dept. Ent., Clemson College, S. Car. *Carabidæ.*
'23. Duncan, Carl D., Box 4, Stanford Univ., Calif. *Vespidæ, Bembicida.*
'30. Dunn, Lawrence H., c/o Gorgas Mem. Labr'y., Box 5025, Ancon, Canal Zone.
'24. Dunn, Melvin B., Ent. Branch, Dept. Agr., Ottawa, Canada. *Forest Ins.*
'28. Dunman, Erastus W., Tallulah, La. *Cotton Insects.*
'16. DuPorte, E. Melville, McDonald College, Quebec, Canada. *Dipt., Ixodoidea.*
'14. Dusham, E. H., Dept. Ent., State College, Pa. *Coleoptera.*

'29. Eagleson, C. W., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Physiol.*
Ch. Eason, N. S., 458 High Street, Fall River, Mass. *Coleoptera.*
'26. Eaton, T. H., Jr., 105 Brandon Pl., Ithaca, N. Y. *Lepidoptera.*
'23. Eddy, C. O., Clemson College, S. Carolina.
Ch. Edwards, Edwin H., 1548 Rockway, Lakewood, Ohio. *Coleopt., Lepidopt.*
'24. Elmore, John C., Box 66, Garden Grove, Calif.
'30. Elmore, L. C., Snowville, Va. *Diptera, Coleoptera.*
'17. Elrod, M. J., State Univ., Missoula, Mont.
'28. Elson, J. A., Gustavus Adolphus College, St. Peter, Minn. *Hemiptera.*
'11. Ely, Charles R., 6 Kendall Green, Washington, D. C. *Gracilariidæ.*
'19. Emerson, A. E., Dept. of Zool., Univ. of Chicago, Chicago, Ill. *Isopt.*
Ch. EMERTON, J. H., 30 Ipswich Street, Boston, Mass. (F. '07). *Spiders.*
'14. Enburg, John M., 5141 Baltimore Ave., Philadelphia, Pa.
'26. Enders, H. E., 249 Littleton St., West Lafayette, Ind. *Mallophaga.*
Ch. Englehardt, G. P., Museum—Eastern Parkway, Brooklyn, N. Y. *Aegeriidæ.*
'26. English, Lester L., Spring Hill, Ala.
'22. Easki, Teiso, Ent. Lab., Kyushu Imp. Univ., Fukuoka, Japan. *Heteroptera.*
'10. ESSIG, E. O., Univ. of Calif., Berkeley, Cal. (F. '27). *Aphididæ, Coccidæ.*
'29. Evans, John H., 502 W. Illinois Street, Urbana, Ill. *Membracidæ.*
'29. Evans, Neal E., 1201 Tennessee St., Lawrence, Kan. *Hydrometridæ.*
Ch. Ewers, Lt. Col. Wm. V., Les Revenants, Somerset, Bermuda.
'10. EWING, H. E., U. S. Nat. Mus., Washington, D. C. (F. '28). *Acarina.*
'18. Eyer, John R., Dept. Biology, State College, New Mexico. *Tineoidea.*

'30. Farquhar, Donald W., 296 Ames Street, Lawrence, Mass.
Ch. FALL, H. C., Tyngsboro, Mass. (F. '07). *Coleoptera.*

'17. Fattig, P. W., Box 788, Emory University, Ga.
'23. Faz, Alfredo, Calle Bandera No. 714, Santiago. Chile, South America.
Ch. FELT, E. P., Bartlett Research Lab's, Stamford, Conn. (F. '08). *Itonididæ.*
'15. Fenton, F. A., 1013 Mills Bldg., El Paso, Texas. *Dryinidæ.*
Ch. FERNALD, H. T., Mass. Agr. College, Amherst, Mass. (F. '14). *Sphecidæ.*
'14. Ferris, G. F., Stanford University, Cal. *Coccidæ, Mallophaga, Anoplura.*
'27. Ficht, G. A., U. S. Corn Borer Lab., Box 359, Monroe, Mich.
Ch. Field, W. L. W., Milton Acad., Vose's Lane, Milton, Mass.
'27. Fife, Lorin, 345 N. Third Street, Logan, Utah.
'22. Filinger, Geo. A., Ohio Agr. Exp. Sta., Wooster, Ohio. *Greenhouse. Ins.*
'10. Fink, D. E., Zool. Lab., Univ. of Pa., Philadelphia, Pa. *Ins. Physiology.*
'28. Fisher, C. K., Box 24, Modesto, Calif.
'07. Fisher, W. S., Nat. Mus., Washington, D. C. *Buprestidæ, Cerambycidæ.*
'22. Fletcher, F. C., 1766 James Ave., So., Minneapolis, Minn. *Pselaphidæ.*
'19. Fletcher, R. K., Box 152, Faculty Exc., College Station, Texas. *Homoptera.*
'08. Flint, W. P., State Ent. Bldg., Urbana, Ill.
'19. Florence, Laura, 445 East 65th Street, Apt. 30, New York, N. Y. *Anoplura.*
'23. Fluke, C. L., 1532 Univ. Ave., Madison, Wis. *Syrphidæ, Bombyliidæ.*
Ch. FOLSOM, J. W., Delta Lab., Tallulah, La. (F. '07). *Collembola, Bombyliidæ.*
'08. *Forbes, W. T. M., Roberts Hall, Cornell Univ., Ithaca, N. Y. *Lepidoptera.*
'22. Ford, Norma, Dept. Biol., Univ. of Toronto, Toronto 5, Canada. *Anatomy, Physiology.*
'19. Fournier, Mrs. Gaston, 90 Boul. Malesherbes, Paris 8, France. *Lepidoptera.*
'26. Fouts, Robt. M., 357 N. Harpers Ave., Hollywood, Calif. *Serphoidea.*
'12. Fox, Henry, Jap. Beetle Lab., Moorestown, N. J. *Orthopt., Scarabaeidæ.*
'11. Fracker, S. B., Federal Horticultural Board, Washington, D. C. *Coreidæ.*
'23. Freeborn, Stanley B., Univ. Farm, Davis, Calif. *Culicidæ.*
'22. Friend, Robt. B., Agr. Exp. Sta., New Haven, Conn. *Diptera.*
'14. FRISON, T. H., Nat. Hist. Bldg., Urbana, Ill. (F. '29). *Bremidæ, Evaniidæ.*
Ch. Frost, C. A., 67 Henry Street, Framingham, Mass. *Coleoptera.*
'14. Frost, S. W., Arendtsville, Pa. *Agromyzidæ.*
Ch. Fullaway, D. T., Board of Agr., Box 3319, Honolulu, Hawaii. *Braconidæ.*
'16. Fulton, B. B., State College, Raleigh, N. Car. *Orthoptera.*
'11. FUNKHOUSER, W. D., Univ. of Kentucky, Lexington, Ky. (F. '20). *Membracidæ.*

Ch. GAHAN, A. B., Nat. Mus., Washington, D. C. (F. '28). *Chalcidoidea, Braconidæ.*
'28. Gahm, Otis E., Bur. Ent., Washington, D. C. *Mushroom Insects.*
'16. Gaige, F. M., Mus. of Zool., Univ. of Mich., Ann Arbor, Mich. *Ants.*
'28. Gamble, John T., 64 Eagle Street, Greenville, Pa. *Aquatic Coleoptera.*
'22. Garlick, W. G., Vineland Station, Ontario, Canada. *Tenthredinoidea.*
'14. Garman, Philip, Agr. Exp Sta., New Haven, Conn. *Odonata, Acarina.*
'28. Garrison, G. L., Tallulah, La.
'22. Gehring, John George, Bethel, Maine. *Coleoptera.*
'28. Geist, Robert M., 811 Euclaire Ave., Columbus, Ohio. *Mallophaga.*
'16. Gentner, Louis G., Box 877, Medford, Oregon. *Halticinæ.*
Ch. Gerhard, Wm. J., Field Mus. Nat. Hist., Chicago, Ill. *Hemiptera.*
'22. Gerry, B. I., Bussey Inst., Forest Hills, Mass.
Ch. GIBSON, ARTHUR, Dominion Entomologist, Ottawa, Canada. (F. '17).
'12. Gibson, E. H., 512 Old Orchard Rd., Ten Hills, Baltimore, Md. *Hemipt.*
'30. Gillespie, A. M., Phi Eta Kappa, Univ. Maine, Orono, Me.
Ch. GILLETTE, C. P., Fort Collins, Colo. (F. '07). *Aphididæ.*
'28. Gilliatt, F. C., Ent. Lab., Annapolis Royal, Nova Scotia. *Tortricidæ.*
'22. Gilmer, Paul M., 2303 W. Douglas Ave., Wichita, Kansas.
'16. Glaser, R. W., Rockefeller Med. Res. Inst., Princeton, N. J. *Ins. Diseases.*
'11. Glasgow, Hugh, N. Y. Agr. Exp. Sta., Geneva, N. Y.
'11. Glasgow, R. D., State Education Bldg., Albany, N. Y. *Phyllophaga.*
'21. Good, Henry G., Ala. Poly. Inst., Auburn, Ala. *Coleoptera.*
Ch. Graenicher, S., Box 14, South Miami, Fla. *Muscoidea, Aculeata.*
'24. Graf, John E., Bur. Ent., U. S. Dept. Agr., Washington, D. C.
'17. Graham, S. A., Sch. of Forestry, U. of Mich., Ann Arbor, Mich. *Timber Ins.*
'22. Granovsky, A., 1532 Univ. Ave., Madison, Wis. *Aphididæ.*

'26. Grant, U. S. IV., Nat. Hist. Mus., Balboa Park, San Diego, Calif.
'28. Gray, John, College of Agr., Gainesville, Fla. *Embryology.*
'14. Greene, Charles T., Box 182, College Park, Md. *Diptera.*
'24. Greer, A. H., Room 8, Federal Bldg., El Paso, Tex. *Heterocera, Culicidæ.*
'28. Grimes, Dillard W., Box 125, Durant, Miss.
'19. Griswold, Grace H., Dept. Ent., Cornell Univ., Ithaca, N. Y.
'24. Gui, Harry L., Agr. Exp. St., Wooster, Ohio.
'29. Guthrie, Howard E., Dept. Ent., Iowa Agr. College, Ames, Iowa. *Coccidæ.*
'21. Guyton, F. E., Auburn, Ala. *Cicadellidæ.*
'16. Guyton, T. L., Bur. Pl. Ind., Pa. Dept. of Agr., Harrisburg, Pa. *Aphididæ.*

'26. Haber, Vernon R., Dept. Ent., Pa. St. College, Pa. *Orthroptera.*
'27. Hadden, F. C., Box 411, Honolulu, Hawaii. *Bostrychidæ, Histeridæ.*
'23. Hadley, Charles H., Box 361, Camden, New Jersey.
'24. Haeussler, G. J., V. Mon Toit, Chemin du Tamisier, Antibes, Alps Maritimes, France.
'14. Hagan, Harold R., Wahiawa via Honolulu, Hawaii.
'26. Haigh, Margaret, 462 Garrison W., Dearborn, Mich. *Lepidoptera.*
'29. Haines, K. A., Dept. Ent., Ohio State Univ., Columbus, Ohio.
'26. Hall, David G., Agr. College, Manhattan, Kansas. *Sarcophagidæ.*
'22. Hall, M. C., Bur. Animal Industry, Washington, D. C. *Parasites of Domestic Animals.*
'14. Hallinen, J. E., Coopertown, Okla.
'21. Hallock, H. C., Box 764, Westbury, Long Isl., N. Y. *Sarcophagidæ.*
'14. Hamilton, C. C., Rutgers, New Brunswick, N. J. *Larvæ of Cincindelidæ, Carabidæ.*
'16. Hamlin, J. C., 473 Fourth Ave., Salt Lake City, Utah. *Membracidæ, Chelinidæ.*
'22. Hamner, A. L., Box 203, A. & M. College, Miss. *Aphididæ.*
Ch. Hansen, James, St. Johns Univ., Collegeville, Minn.
'30. Hardy, Christine, Chesham, New Hampshire.
'07. *HARNED, R. W., A. & M. College, Miss. (F. '28).
'29. Harries, F. H., 473 Fourth Ave., Salt Lake City, Utah.
'23. Harris, H. M., Dept. Ent., State College, Ames, Iowa. *Hemiptera.*
'28. Harris, J. P., Union Trust Co., Cleveland, Ohio.
'28. Harrison, Perry K., Dept. Ent., Univ. of Maryland, College Park, Md.
'24. Hart, Cecil, 132 N. Third Street, Montibello, Calif.
'20. Hartzell, Albert, Boyce-Thompson Inst., Yonkers, N. Y. *Cicadellidæ.*
'07. Hartzell, F. Z., Agr. Exp. Sta., Geneva, N. Y. *Coleoptera.*
Ch. Haseman, Leonard, Univ. of Missouri, Columbia, Mo. *Psychodidæ.*
'19. Hatch, M. H., Dept. Zool., Univ. of Wash., Seattle, Wash. *Coleoptera.*
'29. Hatfield, Nicholas W., 3302 Fall Creek Blvd., Indianapolis, Ind.
'28. Hawkins, J. H., Agr. Exp. Sta., Orono, Me. *Noctuid Larvæ.*
'19. HAYES, WM. P., Old Law Bldg., Univ. of Ill., Urbana, Ill. (F. '29). *Larvæ.*
Ch. HEADLEE, THOMAS, J., New Brunswick, New Jersey. (F. '20).
'28. Hearle, Eric, Ent. Labr'y, Kamaloop, Brit. Col., Canada. *Biting Flies.*
'27. Hendrickson, Geo. O., Dept. Ent., State College, Ames, Ia. *Ecology.*
'28. Henneberry, T. V., 75 School Street, Manchester, Mass.
Ch. HENSHAW, SAMUEL, 28 Fayerweather Street, Cambridge, Mass. (F. '07).
'29. Hering, Paul E., Dept. Biol., Rensselaer Poly. Inst., Troy, N. Y.
'26. HERMES, W. B., Univ. of Calif., Berkeley, Cal. (F. '29). *Med. Ent.*
'29. Herr, E. A., Exp. Sta., Oak Harbor, Ohio. *Lepidoptera, Diptera.*
Ch. HERRICK, GLENN W., 219 Kelvin Pl., Ithaca, N. Y. (F. '14). *Thysanoptera, Coccidæ.*
'17. Hertzog, P. H., Highstown, New Jersey.
'16. Hess, W. N., Hamilton College, Clinton, N. Y. *Lampyridæ.*
'08. Heywood, Mrs. R. E., The Oaks, Peterson, Iowa. *Odonata.*
'28. Hickman, Jennings R., Normal College, Ypsilanti, Mich. *Haliplidæ.*
'29. Hiestand, Wm. A., Univ. of Wis., Madison, Wis. *Coleoptera.*
'26. Higgins, M. L. J., Rood Ave., Sta. 14½, Windsor, Conn. *Coleoptera.*
'19. Hill, Charles C., 337 Franklin Street, Carlisle, Pa.
'08. Hilton, W. A., 1263 Dartmouth Ave., Claremont, Cal. *Compodea, Japyx.*

'28. Hiltz, J. R., 240 Florence Ave., Pontiac, Mich.
Ch. HINDS, W. E., State Univ., Baton Rouge, La. (F. '25).
Ch. Hine, J. S., Archaeol. Mus., Ohio State Univ., Columbus, Ohio. *Diptera.*
'28. Hinman, E. H., 105 N. Quarry Street, Ithaca, N. Y. *Culicidæ.*
'27. Hockenyos, George L., 1003 Oregon Street, Urbana, Ill.
Ch. Hodgkiss, H. E., Exp. Sta. Bldg., State College, Pa. *Eriophyidæ.*
'29. Hodsom, Alex. C., Zool. Dept., U. of Minn., Minneapolis, Minn. *Trichopt.*
'29. Hodson, Elmer C., 48 Sherwood Street, Roslindale, Mass.
'14. *Hoffman, Wm. A., School of Trop. Med., San Juan, P. R. *Biting Flies.*
'29. Hoffman, Clarence H., 1133 Rhode Island St., Lawrence, Kansas.
'19. Hoffman, W. E., c/o Trustees, Lingnan Univ., 150 5th Ave., New York, N. Y. *Hemipt.*
'28. Holdaway, F. G., Faculte des Sci. Zoo., Univ. de Toulouse, Allee St. Michel, Toulouse, France.
Ch. HOLLAND, W. J., Carnegie Mus., Pittsburgh, Pa. (F. '07). *Lepidoptera.*
'13. Holoway, T. E., 8203 Oak Street, New Orleans, La.
'12. Hood, C. E., Melrose Highlands, Mass.
Ch. Hood, J. D., Dept. Biol., Univ. of Rochester, Rochester, N. Y. *Thysanopt.*
'28. Hopping, Ralph, Box 308, Vernon, Brit. Col., Canada. *Timber Ins.*
'13. Horton, J. R., 126 S. Minneapolis, Ave., Wichita, Kan. *Phyllophaga, Ants.*
'23. Hottes, F. C., Dept. Biol., Jas. Millikan Univ., Decatur, Ill. *Aphidadæ.*
'24. Hough, Walter S., Winchester, Va. *Apple Insects.*
Ch. Houser, J. S., Ohio Agr. Exp. Sta., Wooster, Ohio. *Coccidæ.*
Ch. Howard. Chas. T., 36 Colby Street, Rochester, N. Y. *Lepidoptera.*
Ch. HOWARD, L. O., Bur. Ent., Washington, D. C. (F. '07; H. F. '24). *Chalcidoidea.*
'14. Howard, Neale F., 151 West 11th Ave., Columbus, Ohio. *Mex. Bean Beetle.*
Ch. Huard, V. A., 2 Richelieu Street, Quebec, Canada. *Lepidoptera.*
'23. Hubbell, T. H., Dept. Biol., Univ. of Fla., Gainesville, Fla. *Orthoptera.*
'21. Huber, L. L.. Agr. Exp. Sta., Wooster, Ohio. *Chalcidoidea.*
'19. Huckett, H. C., R. D., Calverton, Long Isl., N. Y. *Anthomyiidæ, Muscids.*
'28. Hudson, H. F., R. R. 2, Strathroy, Ontario, Canada. *Noctuidæ.*
'22. Hull, Frank M., Plant Lice Lab., Dickinson, Texas. *Diptera.*
'09. Hungate, J. W., State Normal School, Cheney, Washington.
'16. HUNGERFORD, H. B., Mus. Bldg., K. U., Lawrence, Kan. (F. '28). *Aq. Hemipt.*
Ch. HUNTER, S. J., Lawrence, Kansas. (F. '21).
'17. Hussey, R. F., Dept. Biol., New York Univ., Wash. Sq., New York, N. Y. *Hemipt.*
'26. Hutchinson, W. L., 93 N. Church Street, Hazleton, Pa. *Coleoptera.*
'08. Hyslop, J. A , Silver Spring, Md. *Elateridæ.*

'11. *Illingworth, J. F., Bishop Museum, Honolulu, Hawaii. *Muscoidea.*
'28. Inaba, Naomichi, 207 Harajiku Akasaka, Tokyo, Japan. *Lepidoptera.*
'28. Ingram, J. W., 8203 Oak Street, New Orleans, La.
'26. Irish, Henry Clay, 911 Locust Street, St. Louis, Missouri.
'14. Isely, Dwight, 3 N. Duncan St., Fayetteville, Ark. *Chrysomilidæ.*
'22. Ishimori, Naoto, Faculty of Agr., Imp. Univ., Tokyo, Japan. *Lepidopt.*
'27. Ives, J. D., Carson & Newman College, Jefferson City, Tenn. *Cave Ins.*

'07. Jackson, C. F., Durham, N. H. *Ecology.*
'15. Jackson, L. O., High Sch., Colorado Springs, Col. *Hymenopt.*
'28. Jahn, Lydia A., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Diptera.*
'24. Janvrin, E. R. P., 38 E. 85th Street, New York, N. Y. *Coleoptera.*
'30. Jaynes, H. A., Casilla Correo 74, Tucuman, Argentina, South America.
'25. Jeannel, R., Mus. D'Hist. Nat., 57 Rue Cuvier, Paris 5, Fr. *Trechus, Anophthalmes.*
'10. Jennings, H. R., High Sch., Hayes & Van Ness Ave., San Francisco, Cal. *Dipt.*
'15. Jewett, H. H., 112 State Street, Lexington, Kentucky.
Ch. JOHANNSEN, O. A., Dept. Ent., Cornell, Ithaca, N. Y. (F. '14). *Dipt.*
Ch. JOHNSON, C. W., Soc. Nat. Hist., 234 Berkeley St., Boston, Mass. (F. '07). *Dipt.*

'26. Johnson, Frank, Room 1775, 50 Church Street, New York, N. Y.
'27. Johnston, H. G., Dept. Ent., College Station, Texas. *Miridæ.*
'26. Jones, Dettmar W., 10 Court Street, Arlington, Mass. *Tachinidæ.*
'29. Jones, Edward W., Dept. Ent., Univ. Farm, St. Paul, Minn. *Elateridæ.*
'28. Jones, Elmer T., 126 S. Minneapolis, Ave., Wichita, Kansas.
Ch. Jones, Frank M., 2000 Riverview, Ave., Wilmington, Del. *Psychidæ.*
*'28. Jones, Luther G., Drawer 359, Monroe, Michigan.
'28. Jones, R. M., State Fruit Exp. Sta., Mountain Grove, Mo.
'26. Jones, W. Russel, R. F. D., 11, Box 63-B, Pensacola, Fla. *Hymenopt.*

'16. Kahl, Hugo, Carnegie Mus., Pittsburgh, Pa. *Odonata.*
'27. Kamal, Mohammed, Cotton Res. Board, Giza, Egypt. *Syrphidæ, Coccidæ.*
'29. Keck, Chester B., Box 491, Orlando, Fla.
Ch. KELLOGG, VERNON, Nat. Res. Council, 1701 Mass. Ave., Washington, D. C. (F. '07).
'23. Kelley, E. G., State Agr. College, Manhattan, Kansas.
'24. Kelsheimer, E. G., Corn Borer Lab., Oak Harbor, Ohio. *Behavior.*
'14. KENNEDY, C. H., Ohio State Univ., Columbus, Ohio. (F. '28). *Odonata.*
Ch. Kincaid, Trevor, Univ. of Wash., Seattle, Wash. *Psychodidæ, Tenthredionidea.*
'28. King, Geo. E., c/o Chazy Orchards Inc., Chazy, N. Y. *Hymenoptera.*
'14. King, H. H., Wellcome Trop. Res. Lab., Khartum, Sudan, Afr. *Dipt.*
'12. King, J. L., Jap. Beetle Lab., Moorestown, New Jersey. *Diptera.*
'23. King, K. M., Univ. Sask., Saskatoon, Sask., Canada. *Noctuidæ, Cicadellidæ.*
'28. King, Willard V., Mound, La.
'18. KINSEY, ALFRED C., Ind. Univ., Bloomington, Ind. (F. '28). *Cynipidæ.*
'28. Kislanko, J. P., Box 88, Wiggins, Miss. *Aphididæ.*
Ch. KNAUS, W., McPherson, Kansas. (F. '20). *Coleoptera.*
'11. KNIGHT, HARRY H., State Univ., Ames, Iowa. (F. '28). *Miridæ.*
'24. Knowlton, Geo. F., Utah Agr. Exp., Logan, Utah. *Aphididæ.*
'26. Kofoid, Charles A., Univ. of Calif., Berkeley, Calif. *Termitidæ.*
'17. Kraatz, Walter C., Univ. of Akron, Akron, Ohio.
'23. Kuwayama, Satoru, Hokkaido Agr. Exp. Sta., Kotoni, Saporo, Japan. *Neuroptera, Trichoptera, Psyllidæ.*

'14. Laake, E. W., Box 208, Dallas, Texas. *Larval Muscidæ, Oestridæ.*
'24. Lacey, John S., 133 Waldo Street, Holyoke, Mass.
'19. LaCroix, D. S., 24 N. Prospect Street, Amherst, Mass.
Ch. Lagai, George, 8533-110th St., Richmond Hill, L. I., N. Y. *Lepidopt.*
'28. Lamiman, J. F., 210 Agr. Hall, Univ. Calif., Berkeley, Cal. *Acarina.*
'12. Lamkey, Ernest M. R., 505 So. Fell Ave., Normal, Ill.
'28. Lancaster, Horace, Parma, Idaho. *Thysanoptera, Elateridæ.*
'30. Landis, B. J., 153 Calzada Tacuba, San Jacinto, Mexico City. Mex.
Ch. Lang, Joseph N., 1433 S. 59th Ave., Cicero, Ill. *Lepidoptera.*
'17. Lange, R. C., 527 Ivanhoe Pl., Webster Groves, Mo. *Coleopt., Lepidopt.*
'26. Langford, Geo. S., Dept. Ent., Univ. Maryland, College Park, Md.
'17. Langston, J. M., Box 1, A. & M. College, Miss. *Phyllophaga.*
'14. Larrimer, W. H., Bur. Ent., Washington, D. C. *Cicadellidæ.*
'26. Larson, Andrew O., 1218 Eye Street, Modesto, Calif.
'13. Lathrop, F. H., 1237 Fairground Ave., Vincennes, Ind. *Cicadellidæ.*
'19. Lathy, P. I., 90 Bd. Malesherbes, Paris, France. *Lepidoptera.*
'24. Lattimore, Robt. B., 801 Smith Young Tower, San Antonio, Texas.
'23. Lauderdale, Jos. L. E., Box 368, Yuma, Arizona.
Ch. Laurent, Philip, 31 E. Mt. Airy Ave., Philadelphia, Pa.
'27. Lawler, Wm. F., Jr., 38 Murray Street, New York, N. Y. *Satyridæ.*
'17. Lawson, Paul B., 605 Main Street, Lawrence, Kansas. *Cicadellidæ.*
'26. Leach, Frank A., Diable Country Club, Diable, Calif.
'22. Learned, Elmer T., 46 Franklin Street, Fall River, Mass. *Lepidoptera.*
'12. Leiby, R. W., State Dept. Agr., Raleigh, N. Car. *Polyembryony.*
'28. Leonard, M. D., Tobacco By-Products & Chem. Corp., Louisville, Ky.
'27. Letl, Frank H., Dept. of Preparation, Field Museum, Chicago, Ill.
'27. Light, S. F., Dept. Zool., Univ. Calif., Berkeley, Calif. *Isoptera.*

'17. Lindsey, A. W., Box 782, Granville, Ohio. *Hesperioidea.*
'26. List, George M., Colo. Agr. College, Ft. Collins, Colo. *Cimicidæ.*
'24. Liu, Chung Lo, Dept. Biol., Tsing Hua College, Peking, China. *Vespidæ, Bombidæ.*
Ch. Lloyd, J. T., 6624 Kennedy Ave., Cincinnati, Ohio. *Trichoptera.*
'19. Lobdell, Gladys H., Belle Glade, Fla. *Coccidæ, Aleurodidæ.*
Ch. Lockwood, Stewart, 4232 San Benito, Sacramento, Calif.
'30. Loftin, U. C., Sugar Club Exp. Sta., Cent. Baragua, Prov. Camaguey, Cuba.
'26. Long, William W., Eighty-Four, Pa. *Lepidoptera.*
'29. Lott, Earl, 512 Morgan Ave., Palmyra, N. J.
'19. Lowry, P. R., Univ. New Hampshire, Durham, N. H. *Insecticides.*
'13. Luginbill, Philip, 463 Michigan Ave., Monroe, Michigan. *Phyllophaga.*
'17. Lundbeck, Wm., Zool. Mus., Univ. Copenhagen, Copenhagen, Denmark. *Dipt.*
Ch. LUTZ, FRANK E., Amer. Mus. Nat'l Hist., New York, N. Y. (F. '17) *Bees.*

'28. MacAloney, H. J., Northeast. Forest Exp. Sta., Amherst, Mass. *Timber Ins.*
'28. MacAndrews, A. H., Coll. of Forestry, Syracuse, N. Y. *Timber Ins.*
'24. Macdougal, Alice P., Biol. Dept., Univ. Toronto, Toronto, Canada. *Hemipt.*
'14. McAtee, W. L., Biol. Surv., Dept. Agr., Washington, D. C. *Hemipt.*
'20. McBride, O. C., Box 491, Orlando, Fla.
'29. McClanahan, Annie L., Box 184, A. & M. College, Miss.
'29. McClure, H. E., 925 W. Wood Street, Decatur, Ill.
'17. McCracken, Isabel, Box 44, Stanford Univ., Cal. *Cynipidæ, Apoidea.*
'10. McDaniel, Eugenia I., Agr. College, East Lansing, Mich. *Coccidæ, Orthopt.*
'12. McDUNNOUGH, J., Dept. Agr., Ottawa, Can. (F. '20). *Lepidopt., Ephemerida.*
'25. McGeoch, Charles R., Amherst Agr. College, Amherst, Mass.
'29. McGovran, Edw. R., Dept. Ent., Iowa State College, Ames, Iowa.
'25. McGregor, Ernest A., Box 576, Lindsay, Calif. *Tetranychidæ.*
'29. McIlroy, Wm. D., Jr., 192 Prospect Ave., Ingram, Pa. *Hymenoptera.*
'11. McIndoo, N. E., 7225 Blair Rd., Takoma Park, Washington, D. C. *Physiology.*

'17. Maheux, Georges, Dept. Agr., Parliament Bldg. Quebec, Can. *Timber Ins.*
'28. Maloney, Geo. A., Tallulah, La.
'22. Mank, Edith W., 12 Reservoir Street, Lawrence, Mass. *Coleoptera.*
'21. Mank, Helen G., 12 Reservoir Street, Lawrence, Mass.
'13. *Mann, William M., Nat. Zool. Park, Washington, D. C. *Formicidæ.*
'23. Manter, Jerauld A., Agr. College, Storrs, Conn.
'22. Marcovitch, Simon, Agr. Exp. Sta., Knoxville, Tenn.
Ch. MARLATT, C. L., 1521 16th St., N. W., Washington, D. C. (F. '08). *Coccidæ.*
'24. Marshall, M. C., 1096 Ocean Ave., Brooklyn, N. Y.
Ch. MARSHALL, W. S., 139 E. Gilman St., Madison, Wis. (F. '17). *Morphology.*
'26. Martin, Chas. H., 634 S. Washington Ave., Whittier, Calif.
'28. Marvin, Geo. E., 1532 Univ. Ave., Madison, Wis.
'21. Mason, Arthur C., Box 340, Honolulu, Hawaii. *Thysanoptera.*
'12. Mason, P. W., Bur. Ent., Washington, D. C. *Aphididæ.*
Ch. MATHESON, ROBT., Cornell, Univ. Ithaca, N. Y. (F. '28). *Ixodoidea, Culicidæ.*
'28. Maughan, F. B., Wellsville, Utah.
'28. Mayer, Chas. C. B., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Homoptera.*
'28. Maynard, E. A., Dept. Zool., Univ. Rochester, Rochester, N. Y. *Collembola.*
'26. Meiners, Edwin P., 6600 Delmar Blvd., St. Louis, Mo. *Lepidoptera.*
Ch. MELANDER, A. L., Coll. of N. Y. City, St. Nicholas Ter. & 139th St., New York City. (F. '14). *Dipt.*
'28. Melvin, Roy, Dept. Ent., State College, Ames, Iowa. *Physiology.*
'23. Merrill, G. B., State Plant Board, Gainesville, Fla. *Coccidæ, Aleyrodidæ.*
'12. METCALF, C. L., Old Law Bldg., Univ. Ill., Urbana, Ill. (F. '20). *Syrphidæ.*
'09. Metcalf, Z. P., State College Sta., Raleigh, N. Car. *Homoptera.*
'17. Mickel, C. E., Ent. Dept., Univ. Farm, St Paul, Minn. *Mutillidæ.*
'21. Miller, August E., North Maple Ave., Zanesville, Ohio. *Acarina.*
'28. Miller, D. F., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Ins. Physiol.*

Ch. Miller, Mrs. Ellen R., Lake Wildmere, Longwood, Fla. *Lepidoptera.*
'28. Miller, R. L., State Plant Board, Gainesville, Fla.
'26. Miller, W. C., Bedford High School, Bedford, Ohio. *Hymenopt., Coleopt.*
'29. Mills, H. B., Sci. Bldg., State College, Ames, Ia. *Collembola, Membracidæ.*
'26. Mills, Wier R., Pierson, Iowa. *Lepidoptera.*
'26. Milum, Vern G., 110 Vivarium Bldg., Champaign, Ill. *Apiculture.*
'26. Minnich, D. E., Dept. Zool., Univ. Minn., Minneapolis, Minn. *Behavior.*
'21. Mitchell, Theo. B., N. Car. State College, Raleigh, N. Car. *Apoidea.*
'30. Miwa, Yushiro, Dept. Agr., Gov. Research Inst., Taihoku, Formosa.
'21. *Moffatt, Eliz. M., 1315 Crown Hill Ave., Los Angeles, Cal. *Araneida.*
'28. Mohr, Carl O., State Ent. Bldg., Urbana, Ill. *Coleoptera.*
'22. Montgomery, B. E., Dept. Ent., Purdue Univ., LaFayette, Ind. *Odonata.*
'29. Moody, D. L., Box 133, Presidio, Texas. *Hemiptera, Coleoptera.*
'08. Moore, Wm., 535 Fifth Ave., New York, N. Y. *Insecticides.*
'28. Moreland, R. W., Tallulah, La.
'08. Morgan, Ann H., Mt. Holyoke College, South Hadley, Mass. *Ephemerida.*
Ch. Morgan, H. A., Univ. of Tennessee, Knoxville, Tenn.
'28. Morgan, W. P., 4105 Otterbein Ave., Indianapolis, Ind. *Dermaptera.*
'28. Morofsky, W. F., Box 771, East Lansing, Mich. *Forest Insects.*
Ch. Morrill, A. W., 1505 Winchester Ave., Glendale, Calif.
'12. MORRISON, HAROLD, Bur. Ent., Washington, D. C. (F. '28). *Coccidæ.*
Ch. MORSE, Albert P., Peabody Museum, Salem, Mass. (F. '14). *Orthoptera.*
'08. MOSHER, EDNA, Adelphi, 282 Lafayette Ave., Brooklyn, N. Y. (F. '20). *Lepidopt.*
'20. Mote, Don C., Oregon Agr. College, Corvallis, Oregon.
'29. Moulton, Dudley, 149 California St., San Francisco, Cal. *Thysanopt.*
'26. Muchmore, L. J., 2009 W. 65th St., Los Angeles, Cal. *Coleopt., Araneida.*
'26. Mueller, Arthur E., 12 Armin Ave., Webster Groves, Mo.
'15. Muesebeck, C. F. W., 17 E. Highland Ave., Melrose Highlands, Mass. *Braconidæ.*
Ch. MUIR, FREDERICK, Manoa, Durfold Hill, Warnham, Sussex, England. (F. '17). *Fulgoridæ.*
'24. Munro, H. K., Box 513, Pretoria, S. Africa. *Trypetidæ.*
'27. Munro, J. A., State College Sta., Fargo, N. D. *Orthopt., Dipt.*
'28. Murphy, Helen E., Washington College, Chestertown, Mo. *Ephemerida.*
'28. Musgrave, P. N., 514 Mt. Vernon Ave., Fairmont, W. Va. *Chrysomelidæ.*
'17. Mutchler, A. J., Amer. Mus. Nat. Hist., New York, N. Y. *Lampyridæ, Cicindelidæ.*
'15. Muttkowski, R. A., Univ. of Detroit, Detroit, Mich. *Ins. Physiol.*

'30. Nash, R. W., Forest Service Office, State House, Augusta, Maine.
Ch. NEEDHAM, J. G., 6 Thurston Ave., Ithaca, N. Y. (F. '07). *Odonata, Ephemerida, Plecopt.*
'27. Needham, P. R., 60 Harlem Street, Rochester, N. Y. *Ecology.*
'21. Neilson, Ernst A., 143-16 97th Ave., Jamaica, L. I., N. Y.
'21. Neiswander, C. R., Oak Harbor, Ohio. *Aquatic Hemiptera.*
'28. Neiswander, R. B., Dept. Ent., Agr. Exp. Sta., Wooster, Ohio.
'07. Nelson, Jas. A., Route 3, Mt. Vernon, Ohio.
Ch. Ness, H., 821 Kellogg Ave., Ames, Iowa.
Ch. Newcomb, W. W., 1245 Ferdon Rd., Ann Arbor, Mich. *Lepidoptera.*
Ch. Newcomer, E. J., Box 243, Yakima, Washington.
'07. Newell, Wilmon, Florida Agr. Exp. Sta., Gainesville, Fla.
'15. Newman, Geo. B., 125 W. Beaver Ave., State College, Pa. *Ins. Histology.*
'28. Newton, Richard C., Fernald Hall M. A. C., Amherst, Mass. *Trichoptera.*
'28. Nichol, A. A., Agr. Exp. Sta., Tucson, Ariz. *Coccidæ, Miridæ.*
'22. Noble, W. B., Box 495, West Lafayette, Ind.
'17. *Notman, Howard, 136 Joralemon Street, Brooklyn, N. Y. *Staphylinidæ.*

'28. O'Dell, J. H., Box 1857, Phoenix, Ariz.
'08. O'KANE, WALTER C., Durham, N. H. (F. '25).
'16. Olsen, C. E., Amer. Mus. Nat. Hist., West 77th St., New York, N. Y. *Homopt.*

'29. Oman, Paul W., 925 Indiana Street, Lawrence, Kan. *Homoptera.*
Ch. OSBORN, HERBERT, Ohio State Univ., Columbus, Ohio. (F. '07; H. F. '28). *Cicadellidæ.*
'08. Osborn, H. T., Box 208, Central Aguirre, Porto Rico. *Sugar Cane Ins.*
Ch. OSBURN, R. C., Ohio State Univ., Columbus, Ohio. (F. '17). *Syrphidæ.*
'20. Otanes, Faustino Q., Bur. of Agr., Manila, P. I.
'17. Ouellett, J. C., Deaf & Dumb Inst., 7400 Boul. St. Laurent, Montreal, Can.
'26. Ozburn, Reginald H., Ontario Agr. College, Guelph, Ontario, Canada.

'15. Packard, Clyde M., Box 495, West Lafayette, Ind. *Orthoptera.*
'18. Painter, H. R., Box 495, West Lafayette, Ind. *Orthoptera.*
'19. Painter, R. H., Ent. Dept., Agr. College, Manhattan, Kan. *Bombylidæ.*
'23. Pallister, J. C., Mus. Nat. Hist., 2717 Euclid Ave., Cleveland, Ohio. *Coleopt.*
'28. Palmer, M. A., Dept. Ent., Agr. College, Ft. Collins, Colo. *Coleopt.*
'28. Park, A. R., Jr., State Nat. Hist. Surv., Urbana, Ill. *Ichneumonidæ.*
'27. Park, Orlando, Dept. Biol., Kent State College, Kent, Ohio. *Lampyridæ.*
'24. Parker, Donald L., 17 East Highland Ave., Melrose Highlands, Mass.
'26. Parker, Harry L., European Parasite Lab., Mont Fenouillet, Hyeres, Var. France. *Behavior.*
'18. Parker, J. B., 1217 Lawrence St., N. E., Washington, D. C. *Bembicidæ.*
'24. Parker, R. L., Dept. Ent., Agr. College, Manhattan, Kan. *Apiculture.*
'16. Parker, R. R., U. S. P. H. S., Hamilton, Mont. *Sarcophagidæ, Acarina.*
'16. Parks, H. B., R. R. 1, Box 368, San Antonio, Texas. *Apiculture.*
'18. Parks, T. H., Dept. Ent., Ohio State Univ., Columbus, Ohio.
'14. Parman, D. C., Box 509, Uvalde, Texas. *Diptera, Siphonoptera.*
Ch. PARROTT, P. J., New York Agr. Exp. Sta., Geneva, N. Y. (F. '14).
'12. Parshley, H. M., Smith College, Northampton, Mass. *Heteroptera.*
Ch. *PATCH, EDITH M., Agr. Exp. Sta., Orono, Me. (F. '14). *Aphididæ.*
'26. Patch, Lawrence H., Box 976, Sandusky, Ohio.
'27. Pate, V. S. L., 5703 N. 6th St., Philadelphia, Pa. *Oxybelinæ, Larrida.*
Ch. Paxson, Owen S., Radnor, Delaware Co., Pa.
'23. Payne, Nellie M., 431 Pottawatomie Ave., Manhattan, Kan. *Trichopt.*
'19. Peairs, L. M., Morgantown, West Va.
'24. Peltier, Paul X., Snow Hill, Maryland.
'28. Pepper, John O., Agr. Exp. Sta., State College, Pa. *Cicadellidæ.*
'29. Peters, Harold T., 1709 Louisana Street, Lawrence, Kansas.
'11. PETERSON, ALVAH, Dept. Ent., Ohio State Univ., Columbus, Ohio. (F. '28).
'07. Petrunkevitch, Alex., Osborn Lab., Yale, New Haven, Conn. *Arachnida.*
Ch. Pettit, R. H., Mich. Agr. Exp. Sta., East Lansing, Mich. *Coccidæ.*
'29. Phillips, Arthur M., Box 2080, Orlando, Fla. *Dipt., Coleopt.*
'21. PHILLIPS, E. F., Cornell Univ., Ithaca, N. Y. (F. '29). *Apiculture.*
'29. Philipps, Griffin L., Baldwyn, Miss.
'12. Philips, W. J., U. S. Ent. Lab., Box 592, Charlottesville, Va. *Harmolita.*
'26. Phipps, Clarence R., Agr. Exp. Sta., Orono, Maine. *Noctuidæ.*
'29. Piatt, Jean, 344 Northern Ave., Indianapolis, Ind. *Odonata, Coleopt.*
Ch. Pierce, W. Dwight, 1531 South 19th St., Lincoln, Neb. *Strepsipt.*
'28. Plank, H. K., Trop. Plant Res. Found., Cent. Baragua, Prov., Camaguey, Cuba. *Parasitic Dipt. & Hymenopt.*
'24. Plath, O. E., 688 Boylston Street, Boston, Mass. *Bremida.*
'28. Plummer, Chas. C., Dept. Ent., Ohio State Univ., Columbus, Ohio.
'26. Polivka, Jos. S., Oak Harbor, Ohio.
'26. Pomeory, Fred Elmer, Bates College, Lewiston, Maine.
'13. Poos, Fred W., Arlington Farm, Rosslyn, Va.
'18. Pope, Thomas E. B., Public Museum, Milwaukee, Wis.
'23. Porter, Bennett A., Bur. Ent., U. S. Dept. Agr., Washington, D. C.
'27. Potts, S. F., 17 E. Highland Ave., Melrose Highlands, Mass.
'26. Powell, Eugene F., 125 Bessey Hall, Univ. Neb., Lincoln, Neb.
Ch. Powell, P. B., Clinton, N. Y.
'25. Powers, Edwin B., Dept. Zool., Univ. Tenn., Knoxville, Tenn.
'16. Price, W. A., Univ. of Kentucky, Lexington, Ky.
'28. Proctor, Wm., Bar Harbor, Maine.

'28. Proper, A. B., 17 E. Highland Ave., Melrose Highlands, Mass. *Parasitic Hymenopt.*
'16. Psota, Frank J., 4046 W. 26th Street, Chicago, Ill. *Cretonidæ.*

Ch. QUAINTANCE, A. L., Bur. Ent., Washington, D. C. (F. '14). *Aleyrodidæ.*

Ch. Ramsden, Chas. T., Box 146, Guantanamo, Cuba. *Lepidoptera.*
'23. Randolph, Abraham M., Casilla I, Validivia, Chile, South America.
'13. RAU, PHIL, 549 E. Argonne Drive, Kirkwood, Mo. (F. '28). *Hymenopt., Behavior.*
'23. Readio, P. H., Dept. Ent., Univ. of Kan., Lawrence, Kan. *Reduviidæ.*
'29. Reed, Lucius B., Box 415, Picayune, Miss. *Lepidoptera.*
'23. Reed, W. D., 712 Elizabeth Street, Fresno, Calif. *Diptera.*
'19. Reeher, Max M., Forest Grove, Oregon.
'23. Reeves, Jos. A., Box 22, Fern Park, Fla. *Chrysomelidæ, Fulgoridæ.*
'08. Regan, W. S., Box 853, Yakima, Washington.
Ch. REHN, J. A. G., Acad. N. S., Logan Sq., Philadelphia, Pa. (F. '14). *Orthopt., Dermapt.*
'30. Richards, A. G., Jr., Dept. Ent., Cornell Univ., Ithaca, N. Y. *Noctuidæ.*
'14. Richardson, C. H., Dept. Ent., State College, Ames, Ia. *Physiology.*
'29. Richardson, H. H., Dept. Zool., State College, Ames, Ia. *Dipt., Coccidæ.*
'28. Richmond, E. A., 39 Newbury St., Brockton, Mass. *Hydrophilidæ.*
'22. Ries, Donald T., 209 E. Foster Ave., State College, Pa. *Siricidæ.*
'28. Rifenburgh, S. A., 246 Martellar St., West Lafayette, Ind. *Siphonapt.*
Ch. Riley, C. F. C., Univ. Manitoba, Winnepeg, Canada. *Gerridæ.*
'28. Riley, H. K., Dept. Ent., Purdue Univ., Lafayette, Ind. *Diptera.*
'29. Riley, Merrill F., Univ. Hawaii, Honolulu, Hawaii. *Coccidæ.*
Ch. RILEY, W. A., Dept. Animal Biol., Univ. Minn., Minneapolis, Minn. (F. '14). *Parasitology.*
'28. Rippey, H. K., 27 Russell St., Box 547, W. Lafayette, Ind. *Forest Ins.*
'14. Ris, F., Rheinau, Kt. Zurich, Switzerland. *Odonata.*
'26. Rivney, Ezekiel, 1301 Quincy St., N. W. Washington, D. C. *Rhipiphoridæ.*
'28. Roberts, Raiford A., Box 509 Uvalde, Texas. *Hymenoptera.*
'15. Robinson, J. M., Dept. Zool., Auburn, Ala. *Coccidæ, Coleoptera.*
'27. Robinson, Wm., 5718 Kenwood Ave., Chicago, Ill. *Physiology.*
'13. Rockwood, L. P., Forest Grove, Oregon. *Noctuidæ, Orthoptera.*
'15. Rogers, J. S., Univ. Fla., Gainesville, Fla. *Tipulidæ.*
'23. Rogers, Leslie, Box 4036, Univ. Tenn., Knoxville, Tenn. *Lepidopt., Orthopt.*
'28. ROHWER, S. A., Bur. Ent., Washington, D. C. (F. '29). *Hymenoptera.*
'28. Roney, James N., Div. Ent., College Station, Tex. *Coccidæ.*
'22. Root, F. M., Sch. Hyg. and Pub. Health, 310 W. Monument St., Baltimore, Md. *Culicidæ.*
'14. Rosenfeld, A. H., 1005 N. O. Bank Bldg., New Orleans, La.
'26. Rosewall, O. W., Dept. Ent., La. State Univ., Baton Rogue, La. *Coleopt., Pentatomidæ.*
'24. Ross, Chas. F., 87 Sumner St., Lee, Mass.
'12. Ross, W. A., Ent. Lab., Vineland Station, Ont., Canada. *Aphididæ.*
'14. Rukes, Herbert, 176-11 33rd Ave., Flushing, Long Isl., N. Y. *Hemiptera.*
Ch. Ruggles, A. G., Univ. Farm, St. Paul, Minn.
Ch. Rumsey, W. E., 415 Park Ave., Morgantown, W. Va.

'29. Sakimura, Kay, Pineapple Exp. Station, Honolulu, Hawaii.
'23. Salman, K. A., 1256 College Ave., Sta. A., Palo Alto, Cal. *Psommocharidæ.*
'28. Salt, George, Farnham House Lab., Farnham Royal, Bucks, England. *Bees.*
Ch. SANDERS, J. G., 1608 Walnut Street, c/o Sun Oil Co., Phila., Pa. (F. '20).
'28. Sanders, Paul D., Univ. Maryland, College Park, Md.
'07. Satterthwait, A. F., 527 Ivanho Place, Webster Groves, Mo. *Calendra.*
'24. Sazama, Robt. F., 2 East Locust Street, Vincennes, Ind.
'29. Scaramuzza, Luis C., Central Jaronu, Prov. de Camaguey, Cuba.
'26. Schear, E. W. D., 107 W. Park St., Westerville, Ohio. *Hemipt., Dipt.*
'29. Schmidt, Carl T., Div. Ent., Univ. Farm, St. Paul, Minn.
'19. Schmieder, Rudolph G., 4351 Pechin Street, Philadelphia, Pa.

Ch. Schoene, W. J., Virginia Agr. Exp. Sta., Blacksburg, Va.
'29. Schroeder, Herman, 1336 Vermont Street, Lawrence, Kansas.
'27. Schwardt, Herbert H., Dept. Ent., State Univ., Fayettsville, Ark.
'28. Schwarz, Ernest, State Game and Fish Dept., Jefferson City, Mo. *Catocala.*
'26. Schwarz, E. K. W., 40 W. 84th Street, Apt. 8A, New York, N. Y.
'27. Schwarz, H. F., Amer. Mus. Nat. Hist., New York, N. Y. *Apoidea.*
'28. Scotland, Minnie B., 42 Continental Ave., Cohoes, N. Y. *Hydroporus.*
'26. Scullen, Herman A., 2003 Western Ave., Corvallis, Oregon. *Hymenoptera.*
'23. Seamans, H. L., Dominion Ent. Lab., Lethbridge, Albt., Canada. *Muscoidea.*
'24. Seeley, Ralph M., 21 Avondale Rd., Avondale Estates, Ga. *Araneida.*
'22. Sellers, Wendell F., 51 Clifford Street, Melrose Highlands, Mass.
'29. Setty, Laurel, R., 1743 Louisana St., Lawrence, Kan. *Mecoptera.*
'08. Severin, H. C., State College, Brookings, S. Dak. *Orthopt., Homopt., Hemipt.*
'07. Shafer, Geo. D., 321 Melville Ave., Palo Alto, Calif.
'19. *Shannon, Raymond C., U. S. Nat. Mus., Washington, D. C. *Diptera.*
'29. Shaw, J. Gilbert, 808 Alabama Street, Lawrence, Kansas.
'28. Shaw, S. A., Hampton, N. H. *Diptera* and *Coleoptera.*
'28. Sheaffer, F. E., 636 W. 38th Street, Indianapolis, Ind.
'28. Sheffield, Stanley S., State Plant Board, Orlando, Fla.
Ch. SHELFORD, VICTOR E., Vivarium Bldg., Champaign, Ill. (F. '20). *Ecology.*
'22. Shepard, Harold H., Box 156, Hyattsville, Md. *Hesperiidæ.*
'17. Sherman, Franklin, Div. Ent., Clemson College, S. Car. *Cicindelidæ, Carabidæ, Cerambycidæ.*
'11. Sherman, John D., Jr., 132 Primrose Ave., Mt. Vernon, N. Y. *Dytiscidæ.*
'28. Shiller, Ivan, 801 Smith Young Tower, San Antonio, Texas.
'23. Shotwell, Robert L., 801—6th So. Bozeman, Mont. *Arcididæ, Coccidæ.*
'28. Shropshire, Weslie H., Box 463, Sta. A., Ames, Iowa.
Ch. Shull, A. Franklin, 431 Highland Rd., Ann Arbor, Mich. *Aphididæ.*
'29. Shull, Wesley E., 121 S. Almon Street, Moscow, Idaho. *Mallophaga.*
'19. Sibley, Chas. K., John Burroughs School, Route 2, Clayton, Mo. *Trichopt.*
'28. Siegler, E. H., Bur. Ent., U. S. Dept. Agr., Washington, D. C.
'15. SILVESTRI, FILIPPO, Scuola Superiore d'Agricoltura, Portici, Italy. (F. '20). *Thysanura, Protura, Termites, Myriapoda.*
'29. Simmons, Perez, 712 Elizabeth Street, Frenso, Calif. *Nitidulidæ.*
'26. Simons, Mrs. Carrie Laura, 4021 Alameda Drive, San Diego, Calif.
'30. Simpson, Geddis, W., Dept. Ent., Cornell Univ., Ithaca, N. Y.
'28. Sleesman, Jay P., Exp. Sta., Wooster, Ohio.
'28. Smith, C. W., 228 Dundas Street, E. Bellville, Ont., Canada. *Tackinidæ.*
'28. Smith, Clifton H., Hooper, Utah. *Thysanoptera.*
'27. Smith, F. F., Arlington Farm, Rosslyn, Va. *Aphididæ.*
'28. Smith, George L., Tallulah, La.
'28. Smith, H. D., European Parasite Lab., Mont Fenouillet, Hyers, Var., France.
Ch. Smith, James A., 414 E. Broad Street, Westfield, New Jersey.
'19. Smith, Marion R., State Plant Board, A. & M. College, Miss. *Formicidæ.*
'14. Smith, R. C., Dept. Ent., Agr. College, Manhattan, Kan. *Neuropt.*
'14. Smulyan, M. T., U. S. Bur. Ent., Melrose Highlands, Mass. *Tenthredinidæ.*
Ch. Smyth, E. A., Jr., Route 2, Box 166, Salem, Va. *Papilionidæ Sphingidæ.*
'18. Snapp, Oliver I., Box 445, Fort Valley, Ga. *Curculionidæ, Ageridæ.*
'24. SNODGRASS, R. E., 3706—13th Street, N. W., Washington, D. C. (F. '28). *Morphology.*
'22. Snyder, Thomas E., Bur. Ent., Washington, D. C. *Isoptera.*
'29. Solberg, A. N., 1307—13th St., North, Fargo, N. Dak. *Ins. Physiology.*
'27. Sorenson, Charles J., Utah Agr. Exp. Sta., Logan, Utah.
'28. Spencer, G. Edward, 36 E. Central Ave., Moorestown, N. J. *Coleopt.*
'14. *Spencer, G. J., Dept. Biol., Univ. B. C., Vancouver, Brit. Col., Canada. *Trypetidæ.*
'19. Spencer, Herbert, Dept. Ent., La. Agr. Exp. Sta., Baton Rouge, La. *Hymenopt.*
Ch. Spooner, Charles S., 1436 Seventh St., Charleston, Ill. *Hemiptera.*
'29. Spruijt, F. J., U. S. Ent. Lab., Box 786, Babylon, N. Y. *Hymenopt. parasites.*
'22. Spuler, Anthony, Wenatchee, Wash. *Diptera Borboridæ.*
'26. Squire, E. H. P., 2 Williams Street, White Plains, N. Y.

'29. Stabe, Henry A., Box 376, Univ. Station, Baton Rouge, La. *Apiculture.*
'10. Stafford, E. W., A. & M. College, Miss. *Acalypterate Muscoids.*
'19. Stahl, C. F., Chadbourn, N. Car.
'19. Stear, J. R., 245-5th Ave., 119 Deeds Street, Ligonier, Pa. *Miridæ.*
'17. Stearns, L. A., Agr. Exp. Sta., Newark, Del. *Cercopidæ, Cicadellidæ.*
'23. Steele, Brandt F., 5703 Washington St., Indianapolis, Ind. *Coleopt.*
'27. Steiner, L. F., Cornelia, Ga.
'29. Steinweden, J. B., 149 California St., R. 420, San Francisco, Cal.
'28. Steine, A. E., R. I. St. Bd. of Agr., Kingston, R. I.
'26. Stephenson, Lyle, 35 West 52nd Street, Kansas City, Mo.
'21. Stevens, O. A., State College Sta., Fargo, N. Dak. *Bees, Wasps.*
'28. Stevenson, W. A., Box 1896, Tuscon, Ariz.
'25. Stewart, Kenneth E., 322 Frank Street, Apt. 7, Ottawa, Canada.
'17. Stickney, Fenner S., 521 N. Pickering Ave., Whittier, Calif. *Coccidæ.*
'15. Stiles, Charles F., Box 37, Stillwater, Okla.
'29. Stirland, L. L., Providence, Utah.
'22. Stirrett, G. M., Corn Borer Lab., Chatham, Ontario. *Halticini, Trichopt.*
'28. Stone, Alan, Dept. Zool., Dartmouth, Hanover, N. Hamp. *Tabanidæ.*
'28. Stone, Marshall W., Box 297, Alhambra, Calif.
'28. Stone, Wm. E., Box 549, Sanford, Fla.
'13. Stoner, Dayton, U. S. Ent. Lab., Sanford, Fla. *Pentatomoidea.*
'28. Street, T. M., N. Dak. School of Forestry, Bottineau, N. Dak.
'12. Strickland, E. H., The University, Edmonton, Alberta, Canada.
'26. Strohecker, H. F., 123 Culver Street, Macon, Ga.
'28. Sullivan, K. C., St. Bd. Agr., Jefferson City, Mo. *Chironomidæ, Culicidæ.*
'08. Summers, J. N., 15 Highland Ave., Melrose Highlands, Mass. *Coccidæ.*
'20. SWAINE, J. M., Dept. Agr., Ottawa, Canada. (F. '21). *Forest Insects.*
'21. Sweet, Miss Georgiana, Clivenden Mansions, East Melbourne C. 2. Victoria, Australia.
'23. Sweetman, H. L., Agr. Exp. Sta., Laramie, Wyoming. *Ecology.*
'20. Swezey, O. H., 2048 Lanihuli Drive, Honolulu, Hawaii. *Lepidoptera.*
'21. Swift, F. R., 205 Brookside Ave., Mt. Vernon, N. Y. *Diptera.*
'22. Swingle, Homer S., Box 247, Auburn, Ala. *Physiology.*
'28. Swinyard, Chester A., 467 Blvd., Logan, Utah. *Homoptera.*
'29. Swope, Edwin, 730 Kentucky Street, Lawrence, Kansas.

'21. Takahashi, Ryoichi, Dept. Agr., Res. Inst., Takhoku, Formosa, Japan. *Aphididæ, Coccidæ.*
'28. Tanner, V. M., Brigham Young Univ.. Provo, Utah. *Tenebrionidæ, Carabidæ.*
Ch. Tanquary, M. C., Dept. Ent., Univ. Farm, St. Paul, Minn. *Formicidæ, Apiculture.*
'22. Taylor, L. H., Dept. Zool., W. Va. Univ., Morgantown, W. Va. *Chrysididæ.*
'29. Taylor, R. L., Maine Forest Serv., Bar Harbor, Me. *Parasitic Hymenopt.*
'21. Thomas, Chas. A., Kennett Sq., Chester Co., Pa. *Collembola, Elateridæ.*
'15. Thomas, F. L., College Station, Texas.
'09. Thomas, W. A., Bur. Ent., Chadbourn, N. Car.
'10. THOMPSON, W. R., Farnham House Lab., Farnham Royal, Bucks, Eng. (F. '27). *Tachinidæ.*
'29. Thomson, Jas. R., Box 445, Fort Valley, Ga.
'22. Tietz, H. M., Dept. Zool., State College, State College, Pa. *Noctuidæ.*
'20. TILLYARD, R. J., Chief Comm. Ent., Canberra F. C. T., Australia. (F. '28). *Fossil Ins., Odonata.*
'11. Timerlake, P. H., Citrus Exp. Sta., Riverside, Cal. *Encyrtidæ.*
'28. Tinkham, E. R., Box 111, Presidio, Tex. *Rhopalocera, Orthopt., Odonata.*
'23. Tissot, Archie N., Fla. Agr. Exp. Sta., Gainesville, Fla. *Aphididæ.*
Ch. Titus, E. G., 417 Beason Bldg., Salt Lake City, Utah. *Apidæ.*
'27. Todd, Frank, E., State Insectary, Sacramento, Calif. *Hymenoptera.*
Ch. *DE LA TORRE BUENO, J. R., 38 De Kalb Ave., White Plains, N. Y. (F. '28). *Aquatic Hemipt.*
'29. Tosawa, Nobuyoshi, 62 Komatsubaracho Kitak, Osaka, Japan. *Hymenopt.*
'28. Townsend, Lee H., Old Law Bldg., Dept. Ent., Univ. Ill., Urbana, Ill.
'21. Townsend, M. T., Histology Dept., Medical Sch., Univ. Okla., Oklahoma City, Okla.

'29. Tsou, Y. H., Bur. Ent., Hangchow, China.
'28. Tullock, Geo. S., Mus. Comp. Zool., Oxford Street, Cambridge, Mass.
'24. Turner, P. A., 355 W. Duval Street, Germantown, Philadelphia, Pa. *Odonata.*
'08. Turner, Wm. F., 208 Anderson Ave., Ft. Valley, Ga.
'29. Tuthill, L. D., 246 East 13th St., Baxter Spgs., Kan. *Cicadellidæ, Fulgoridæ.*

'20. Uichanco, L. B., Coll. Agr., Laguna, P. I. *Thysanopt., Psyllidæ, Aphididæ.*
'17. Urich, F. W., 107 Frederick St., Port of Spain, Trinidad, Brit. West Indies.

'26. Valentine, J. M., 502 North St., Chapel Hill, N. Car. *Cicindelidæ, Carabidæ.*
'22. Vance, Arlo M., Parasite Lab., Le Mont Fenouillet, Hyeres, Var, France.
'29. Vanderford, Henry T., Box 281, A. & M. College, Miss.
Ch. Van Dine, D. L., Cuba Sugar Club Exp. Sta., Cent. Baragua, Camaguay, Cuba.
Ch. VAN DUZEE, E. P., Acad. Sci., G. G. Park, San Francisco, Cal. (F. '12). *Hemiptera.*
'17. Van Duzee, M. C., 12 Abbotsford Place, Buffalo, N. Y. *Dolichopodidæ.*
Ch. VAN DYKE, E. C., Univ. of Calif., Berkeley, Cal. (F. '17). *Coleopt.*
'23. Vellard, Jehan A., Instituto Vital, Brazil, Caixa Postal 28, Nichteroy, Estado do Rio, Brazil. *Arachnida.*
Ch. Vickery, R. A., 801 Smith Young Tower, San Antonio, Texas.
'13. Vorheis, Chas. T., Univ. Ariz., Tucson, Ariz.
'28. Voris, Ralph, State Teachers College, Springfield, Mo. *Staphylinidæ.*

'15. Wade, Jos. S., Bur. Ent., Washington, D. C. *Coleoptera.*
'21. Wadley, F. M., Bur. Ent., Washington, D. C. *Aphididæ.*
'18. Wainwright, C. J., 172 Hamstead Rd., Handsworth, Birmingham, Eng. *Tachinidæ.*
'22. Wakeland, Claude, Dept. Ent., Univ. of Idaho, Moscow, Idaho. *Eleodiini.*
'22. Walkden, Herbert H., 128 S. Minneapolis, Ave., Wichita, Kansas.
'10. WALKER, E. M., Univ. of Toronto, Can. (F. '14). *Odonata, Orthopt.*
'26. Walker, Fred H., Box 456, Salem, Mass. *Bees.*
'23. Walker, Fred W., Box 92, Monticello, Fla. *Orthroptera, Dermapt.*
'29. Wall, Robert E., 1506 Raymond Ave., St. Paul, Minn. *Aphididæ.*
'23. Wallace, Hugh E., Box 703. Riverside, Calif.
'11. Wallis, J. B., 211 Waterloo St., Winnipeg, Can. *Haliplidæ, Dytiscidæ, Gyrinidæ.*
'26. Walton, L. B., Kenyon College, Gambier, Ohio. *Endomychidæ, Thysanura.*
'17. Walton, W. R., Bur. Ent., U. S. Dept. Agr., Washington, D. C.
'13. Watson, J. R., Fla. Agr. Exp. Sta., Gainesville, Fla. *Thysanoptera.*
'26. Watson, S. A., Whittier College, Whittier, Calif. *Miridæ.*
'16. Webber, Ray T., 17 E. Highland Ave., Melrose Highlands, Mass. *Tachinidæ.*
Ch. Webster, R. L., Wash. Agr. Exp. Sta., Pullman, Washington.
'28. Weed, Alfred, Care John Powell & Co., 114 East 32nd St., New York, N. Y. *Conopidæ.*
Ch. WEED, CLARENCE M., State Normal School, Lowell, Mass. (F. '25).
'26. Weeks. Andrew G., Marion, Mass. *Lepidoptera.*
'17. Weese, A. O., Univ. Okla., Norman, Okla. *Ecology.*
'18. Wehrle, L. P., Univ. of Arizona, Tucson, Ariz.
'17. Weigel, Charles A., Bur. Ent., Washington, D. C. *Greenhouse Insects.*
'13. Weiss, H. B., 19 N. 7th Ave., Highland Park, New Brunswick, N. J. *Ecology.*
'12. WELCH, P. S., Univ. Mich., Ann Arbor, Mich. (F. '20). *Aquatic insects.*
'07. Weld, L. H., East Falls Church, Va. *Cynipidæ.*
'22. Wellhouse, W. H., Dept. Ent., Iowa State College, Ames, Iowa.
'12. Wells, M. M., 761 E. 69 Place, Chicago, Ill.
'21. West, L. S., Dept. Biol., Battle Creek College, Battle Creek, Mich. *Muscoidea.*
'18. Whedon, Arthur D., 1145 3rd Street N., Fargo, N. Dak. *Odonata.*
'26. Wheeler, E. H., Ent. Lab., Cornell Univ., Ithaca, N. Y.
'22. Wheeler, Geo. C., University, Grand Forks, N. Dak. *Formicidæ.*
Ch. WHEELER, W. M., Bussey Inst., Boston 30, Mass. (F. '07). *Formicidæ.*
'26. Whelan, Don B., Univ. Neb., Lincoln, Nebraska.

'29. White, R. M., Treebank, Manitoba, Canada. *Leaf-mining insects.*
'22. Whitehead, Fred E., Dept. Ent., Okla. Agr. Exp. Sta., Stillwater, Okla.
Ch. WICKHAM, H. F., 911 E. Iowa Ave., Iowa City, Iowa. (F. '14). *Coleoptera.*
'29. Wilbur, Donald A., Kan. St. Agr. College, Manhattan, Kansas. *Homoptera.*
'29. Wilby, George V., Box 92, N. Dak. Agr. College, Fargo, N. Dak.
'24. Wilcox, Joseph, 31 N. 26th Street, Corvallis, Oregon. *Diptera.*
'17. Wild, Wm., 249 Walnut Street, East Aurora, N. Y. *Microlepidoptera.*
'21. Wiley, Mrs. Grace O., Public Library, Minneapolis, Minn. *Aquatic Hemipt.*
'29. Will[illegible] Homer C., Harrisburg, Pa.
'27. Willard, H. F., Box 340, Honolulu, Hawaii.
'14. WILLIAMS, C. B., 29 Queens Crescent, Edinburgh, Scotland. (F. '20). *Thysanoptera.*
'14. Williams, R. C., 4537 Pine Street, Philadelphia, Pa. *Hesperidæ.*
'17. Williams, S. H., Dept. Zool., Univ. of Pittsburgh, Pittsburgh, Pa. *Coleopt.*
Ch. WILLIAMSON, E. B., Bluffton, Ind. (F. '14). *Odonata.*
'11. Williamson, Warren, R. F. D. 5, Galesburg, Ill.
'23. Willis, Warren J., 24824-89th Ave., Bellerose, N. Y. *Aquatic Insects.*
'23. Wilson, Cecil C., 600—26th Street, Sacramento, Calif. *Orthroptera.*
'26. Wilson, Francis H., Univ. Richmond, Richmond, Va. *Mallophaga.*
Ch. Wilson, H. F., 1532 Univ. Ave., Madison, Wis. *Aphididæ.*
'30. Wilson, John W., Pierson, Florida.
'28. Windsor, Margaret, S. West St., Teachers College, Weatherford, Okla. *Stratiomyiidæ.*
Ch. *Wirtner, M., St. Bonifacius, Cambria Co., Pa. *Hemiptera.*
'28. Wisecup, C. B., Box 549, Sanford, Fla.
Ch. Woglum, R. S., Calif. Fruit Growers' Ex., Los Angeles, Calif.
'08. Wolcott, R. H., Univ. Neb., Lincoln, Neb. *Hydracarina.*
'14. Wood, W. B., Plant Quarantine and Control Admin., Washington, D. C.
'26. Woodruff, Lawrence C., 1212 Louisana Street, Lawrence, Kansas.
'13. Woods, William C., Kent School, Kent, Conn. *Chrysomilidæ.*
'17. Woodworth, C. W., Dept. Ent., Univ. Calif., Berkeley, Calif.
'17. Woodworth, H. E., Calif. Spray Chem. Co., Watsonville, Calif.
'22. Worthley, H. N., Exp. Sta. Bldg., State College, Pa. *Tachinidæ.*
'28. Wray, David L., Jr., Box 834, Shelby, N. Car. *Coleoptera.*

'28. Yeates, J. M., Tallulah, La.
Ch. Yothers, W. W., Box 491, Orlando, Fla.
'23. Young, Hiram C., Box 1896, Tucson, Ariz.
'25. Young, Martin T., Box 165, Tallulah, La.
'17. Yuasa, Hachiro, Imp. Univ., Kyoto, Japan. *Ecology.*

'23. Zebrowski, Geo., Buck Creek, Ind. *Acarina, Hemiptera.*
'21. Zerny, Hans, Burgring 7, Wien 1, Austria. *Heterocera.*
'07. Zetek, James, Drawer C., Ancon, Panama. *Isoptera, Trypetidæ.*
'30. Ziegler, Louis W., Agr. Exp. Sta., Gainesville, Fla.
'27. Zimmer, L. A., Eup. Corn Borer Lab., Oak Harbor, Ohio. *Parasitic Hymenopter*
'21. Zimmerman, Sarah K., 317 Kensington Ave., Astoria, Oregon.

Date of Issue	Date of Issue	Date of Issue
22.12.82	[illegible]	